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THE SURGICAL TREATMENT OF SYRINGOMYELIA*

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AMONG the less common diseases of the spinal cord, syringomyelia occupies an important place. Pathologically, the process is characterized by two changes occurring usually within the cervical cord: (1) Gliosis or a slow proliferation of the supporting glial cells, and (2) cavity formation. The latter is of particular interest to the neurosurgeon. The relative extent of each varies greatly in different cases though both are usually present. While the exact etiology of the disease cannot as yet be conclusively settled, it is probable that it depends primarily upon developmental anomalies of the glial cells along the posterior median raphé of the spinal cord. These abnormalities are doubtless present at birth. Possibly as the result of irritation or trauma, a slow proliferation of the glial cells begins in later life, and in the course of the growth of the lesion secondary degeneration occurs within it and a cavity lined and surrounded by glia is formed. The boundary between intramedullary gliosis and intramedullary gliomas is not always a sharp one, and syringomyelia has been considered by many writers as a neoplastic process, to be differentiated from the usual tumors only by its very slow extension.

Clinically, the patient presents the picture of a slowly developing sensory and later motor loss usually beginning in one upper extremity and accompanied not infrequently by severe aching pain in the neck and shoulders. The location of the pathology in the central portion of the cord produces a characteristic associated sensory change with preservation of touch in areas where pain and temperature stimuli are not perceived. Early in the disease, muscle atrophy and vascular and trophic changes can be detected in the affected extremity. While peculiar remissions and relapses may occur, the symptoms slowly progress, and appear in the lower extremities and opposite side in time. The extension of the disease into the medulla is also not uncommon.

From the standpoint of surgical treatment, two features of the disease deserve emphasis: (1) the progress of syringomyelia both pathologically and clinically is extremely slow, and (2) in many cases a large share of the symptom-complex may be the result of compression of the spinal cord between the distended cavity within and the bony walls of the spinal canal with-

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out. Consequently, if an artificial communication between the intramedullary cyst and the subarachnoid space can be established and this pressure released, great improvement will occur in these patients; an improvement, moreover, which will be maintained for a number of years.

We have in our files the record of a number of operations for syringomyelia; the first operation was performed May 31, 1922, and the last July 31, 1934. Altogether, there were five patients and eight operations; three patients were operated upon at intervals of nine months to two years. Of the five patients, we have been able in three to follow the clinical course from the date of operation to the present time. One patient was operated upon in 1931, but we have been unable to trace him. In one patient, the syringomyelic process was complicated with an internal hydrocephalus and papilledema. Believing the patient had an intracranial lesion, an exploratory craniotomy was performed to which the patient succumbed. The autopsy revealed a syringomyelic cavity of the cord and the internal hydrocephalus proved to be due to a block of the fourth ventricle (Alpers and Comroe).[1] In one case, what was believed to be essentially a true syringomyelia proved later to be a glioma which had undergone cystic degeneration. In several recent cases, too little time has elapsed to evaluate the results. There were no operative deaths in the series.

Our knowledge of the efficacy of surgical measures in the treatment of syringomyelia obviously must depend upon the observation of the patients for at least one year, preferably longer. Unfortunately, the majority of the reports of surgical experiences include only a relatively brief postoperative period. To evaluate the propriety of open drainage, it is essential to consider only late results. With this object in view, two of the five operative cases of this clinic with relatively long periods of observation have been reviewed. Fourteen additional cases in which the period of observation after operation was one year or more have been collected from the reports of other clinics, and the technic and results of the operation will be the subject for discussion.

Case Reports

Case I.—R. S., white female, aged 35 years (No. 18559), was admitted to the Neurosurgical Service of the University Hospital, April 2, 1930.

Summary.—A woman of 35, who slowly developed all of the characteristic neurologic changes of syringomyelia, was first operated upon with drainage of a cervical intramedullary cavity in 1930. She subsequently had less pain and was completely relieved of a distressing incontinence, but almost two years later developed bulbar symptoms which were relieved by a second drainage in 1933. Her improvement after this operation was well maintained for almost two years. Recently, occasional bulbar symptoms have again appeared.

Note.—This case was previously reported (1930, 1933) but is again reviewed for two reasons: (1) Because the preoperative duration of symptoms is longer than in any other reported case, and (2) because it represents an instance of prolonged benefit (four and one-half years) from operation, despite the duration of the lesion.

History.—When first seen, this patient gave a history of 15 years' duration. In 1915, she first observed a tingling sensation in the left arm, followed shortly by a progressive loss of sensation and motor power in both left extremities. The right arm began to show a decrease in strength in 1919, but loss of sensation in this area

did not appear until almost one year later. The progression of these symptoms was very slow from 1928 on, but in 1929 two additional difficulties appeared—clonic spasms of the muscles of the neck and the right shoulder and occasional incontinence of urine. Early in 1930, paresis of the right leg developed and the patient also began to complain of trouble in focusing her eyes.

Examination on Admission in 1930.—At this time, examination showed a marked loss of motor power, the left arm being completely paralyzed and the left leg and right arm about 75 per cent incapacitated, and the right leg slightly below normal in strength. The patient could barely walk a few steps with much assistance. The sensory changes were likewise extensive—all forms of sensation being lost from the face down, with the exception of the left leg, where touch, pain and temperature stimuli were faintly detected by the patient. The face showed a bilateral dissociated sensory loss; touch being preserved and pain and temperature senses much reduced. The extremities, particularly the left shoulder, were atrophied, and spastic contractures were beginning. Hyperactive tendon reflexes, ankle clonus, and a positive Babinski sign were found bilaterally in the lower extremities. Examination of the cranial nerves was negative with the exception of the sensory changes in the face and a marked nystagmus on deviation of the eyes in any direction. Lumbar puncture revealed a spinal fluid pressure of 250 Mm. of water, but curiously enough the Queckenstedt test showed no evidence of a subarachnoid block.

First Operation.—April 14, 1930.—A cervical laminectomy exposed a swollen spinal cord which was incised on the dorsal aspect 1 to 2 Mm. to the right of the midline. At a depth of 2 to 4 Mm., a large cystic cavity was entered, permitting the escape of a considerable amount of fluid. A small gutta percha drain was inserted into the cavity and the dura and remaining layers closed with interrupted silk sutures.

Interval History, 1930–1933.—As had been feared preoperatively there was no great alteration of the long-standing motor and sensory picture. Nevertheless, definite results were obtained, including the relief of spasticity in the hands, a slight improvement in the power of the right side and restoration of touch and temperature sensations in the second and third cervical and in the trigeminal zones. Most encouraging of all, however, and of the greatest importance to the patient, was the complete relief of urinary incontinence.

During the next two and one-half years, the patient's condition changed very little. There was, however, a gradual progression of the weakness of the right extremities, associated with occasional attacks of clonic jerking, for which two series of roentgen ray treatments were given with very little effect. In January, 1933, a rather rapid downhill course began. Ptosis of the right eyelid, huskiness in talking, twitchings of the right side of the face, and attacks consisting of a sense of constriction about the chest associated with labored and irregular respirations, cramp-like pains in the left leg and abdomen appeared.

It seemed probable that there had not only been a rostral progression of the process into the brain stem, but that the syringomyelic cavity had refilled. To confirm the latter hypothesis a needle was introduced through the site of the laminectomy, first into the subarachnoid space and then slightly deeper into the cavity in the spinal cord. Nine cc. of clear fluid containing 10 cells per cc. (as compared with two cells per cc. from the spinal fluid) were evacuated.

Second Operation.—February 2, 1933.—Since the aspiration resulted in slight improvement in the patient's condition, a second cervical laminectomy was proposed. The cervical cord was found to be widened but collapsed (presumably as the result of the evacuation of the cyst by aspiration a few days before). Not the slightest clue as to the site of the previous incision could be detected. However, when an incision 2 cm. in length was made in the spinal cord slightly to the right of the midline, the gutta percha drain of the first operation was discovered partly in the cyst and partly in the wall, though completely covered apparently in part by arachnoid. As far as could be determined grossly, closure of the first drainage opening into the cavity had followed dis-

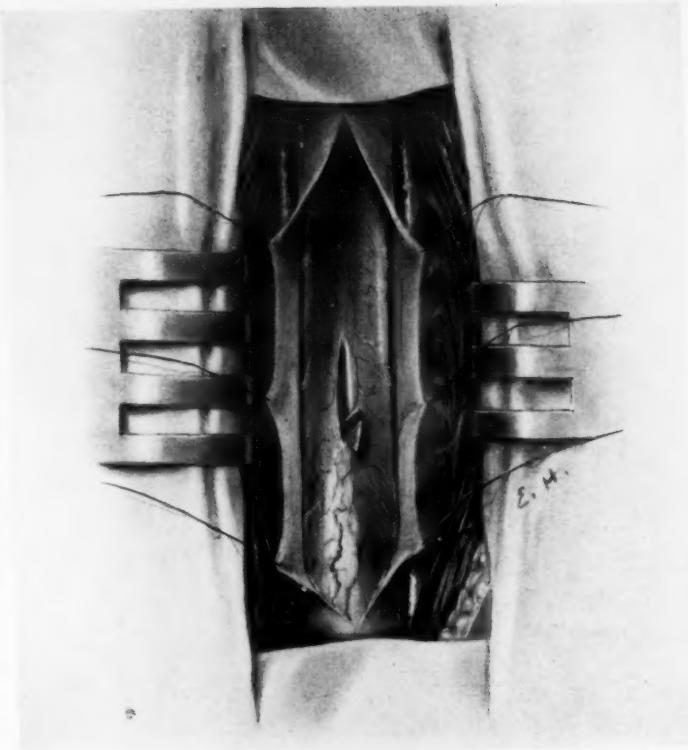

FIG. 1.—The appearance of the spinal cord in Case I after the second operative drainage, showing the collapse of the cord, the incision into the cyst, and the gutta percha drain held in place by one silver clip.

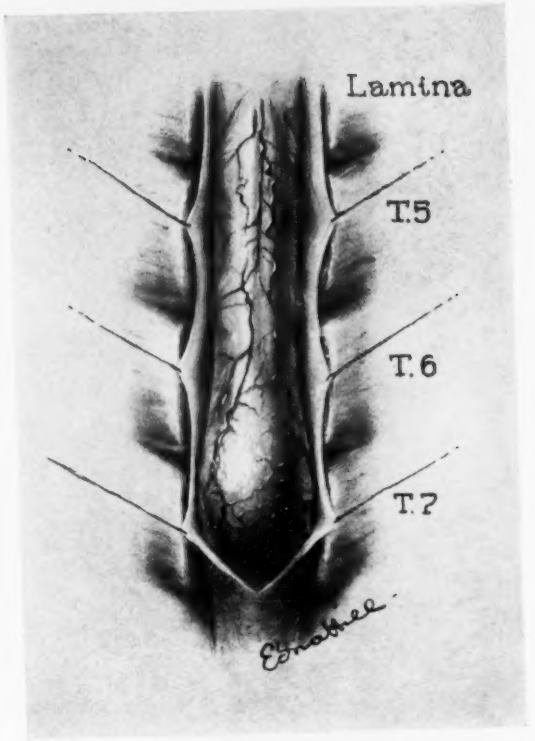

FIG. 2.—The spinal cord as it appeared at the first operation in Case II, showing the marked swelling at the seventh cervical segment.

lodgment of the gutta percha drain into the cavity and a subsequent gliosis and adhesion of the arachnoid. To prevent, if possible, any such dislodgment of the second piece of gutta percha, it was attached to the edge of the opening with a single silver clip (Fig. 1).

Course Following Second Operation.—February, 1933, to January, 1935.—The improvement which followed was again encouraging and more definite than had been expected in the face of the apparent medullary extension of the lesion. The respiratory crises, which had been so exhausting and dangerous, disappeared entirely for over one and a half years, the patient's voice returned to normal and the ptosis of both eyelids disappeared in the course of about six months. These improvements have been maintained with the exception of the attacks of respiratory embarrassment which recently have begun to recur occasionally.

Comment.—There are several somewhat unusual features in this case which deserve brief comment. The long duration of symptoms is characteristic of the slow progress of syringomyelia and might perhaps be considered as an argument against, or as a possible explanation of, the results of surgical intervention. On the other hand, it is encouraging to find that such gratifying improvement in some symptoms may result from operation in the presence even of a long standing process. This patient is one of the few in which a secondary operation has permitted an examination of a myelotomy incision some years after it was made. The finding of the closure of the original incision, as well as the prompt improvement after it was reopened, may be advanced as an argument in favor of repeated drainage in selected cases.

Case II.—L. B., white male, aged 27 years (No. 25711), was admitted to the Neurosurgical Service of the University Hospital, December 26, 1932.

Summary.—This patient suffered from intermittent attacks of neck and shoulder pains associated with paresis at first of the left leg and then the other extremities over a period of four years before admission. The marked motor and sensory losses almost completely disappeared after drainage. His symptoms recurred in ten months and at a second laminectomy an intramedullary cyst 3½ cm. in length was drained. His subsequent return to a nearly normal neurologic status has been maintained for one year and two months.

History.—In 1928, for about one week, the patient first suffered from nocturnal attacks of rather severe aching pains at the base of the neck which radiated over both shoulders. These disappeared spontaneously, but one year later (1929), while playing football, he developed weakness in flexion of the left upper leg. This weakness, which was at first so marked as to make climbing stairs difficult, gradually lessened in the course of six months. With the exception of a brief return of the neck and shoulder pain in December, 1930, the patient was well until October, 1931, when, following an attack of pharyngitis, he suffered first a recurrence of the cervical ache and then developed a complete paralysis of both lower extremities, marked weakness of both hands, and a numbness of the right leg. In the course of about three months, these disturbances slowly cleared up almost entirely, but similar briefer attacks of pain and marked paresis of all extremities occurred more and more frequently during the ensuing year (1932), and he entered the hospital with these symptoms in December, 1932.

Examination on First Admission.—December, 1932.—The patient was found to have a marked motor deficit, including a spastic paraplegia, weakness of flexion, and paralysis of extension in the arms (slightly more complete on the left), with atrophy of the muscles of the forearms and hands. He showed a considerable loss of sensation, pain and temperature sense was absent over C 8 and from D 4 to D 12, and diminished in both lower extremities, particularly in the right. Touch was preserved but somewhat impaired in

the same areas, and vibration sense was lost from D 4 down (Fig. 3). Hyperactive tendon reflexes were found in the lower extremities, and hypo-activity of those of the upper extremities was noted. There were bilateral Babinski and Troemner reflexes, and a bilateral ankle clonus. There were slight changes in the roentgenographic appearance of the second to fifth cervical vertebrae, inclusive. The spinal fluid contained 5.5 units of protein and the Queckenstedt test demonstrated a partial subarachnoid block.

First Operation.—January 6, 1933.—An exploratory laminectomy was performed at which the laminae and spinous processes from C 4 to C 7 were removed. At the level of the seventh cervical cord segment, there were a number of arachnoid adhesions and the spinal cord seemed twice its normal diameter and unusually soft to palpation

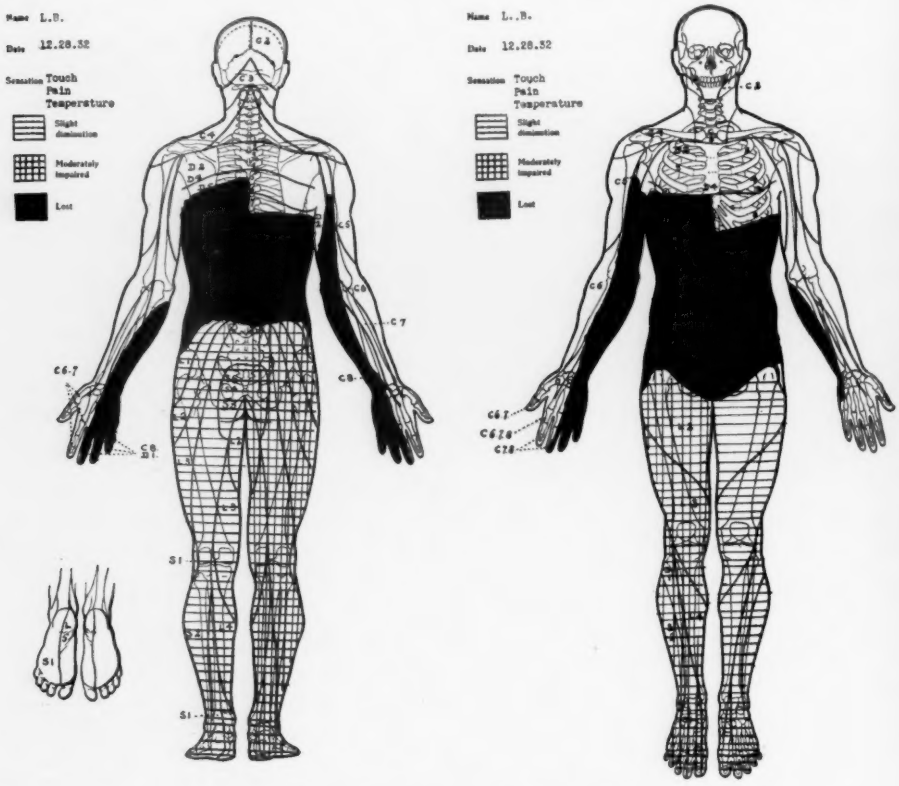

FIG. 3.—(Case II.) Pain sensation on first admission.

(Fig. 2). A hypodermic needle was introduced into the cord and a few drops of blood-tinged fluid were evacuated. When a short median incision was made at this point, a small cyst was encountered 1 Mm. below the surface. Since this cavity did not contain enough fluid to account for the enlargement of the cord, it seemed probable that the process was an intramedullary glioma rather than a syringomyelia. Accordingly, the dura mater was left unsutured and the wound closed.

Interval History.—January to October, 1933.—The surgical recovery was uneventful. Within two days of the operation the patient began to show a surprisingly rapid and extensive neurologic improvement. His sensory changes disappeared almost entirely, and the only remaining evidence of pyramidal tract damage was a left-sided ankle clonus. The improvement continued for six months, the patient being able to walk, swim and run and in general lead a very active life. However, beginning in September,

1933, there was gradual return of the old cervical pain and weakness in the left side, and the patient reentered the hospital.

Examination on Second Admission.—October 10, 1933.—The neurologic changes at this time were found to be slightly less marked than on the first admission, although there was a considerable loss of motor power in all extremities and the sensory impairment was greater than that of the earlier examination (Fig. 4). Since the Queckenstedt test again showed a partial subarachnoid block, and since there seemed some possibility of cyst formation in the lesion, operation was again advised in spite of the previous diagnosis of intramedullary glioma.

Second Operation.—October 28, 1933.—At the second laminectomy, the old wound

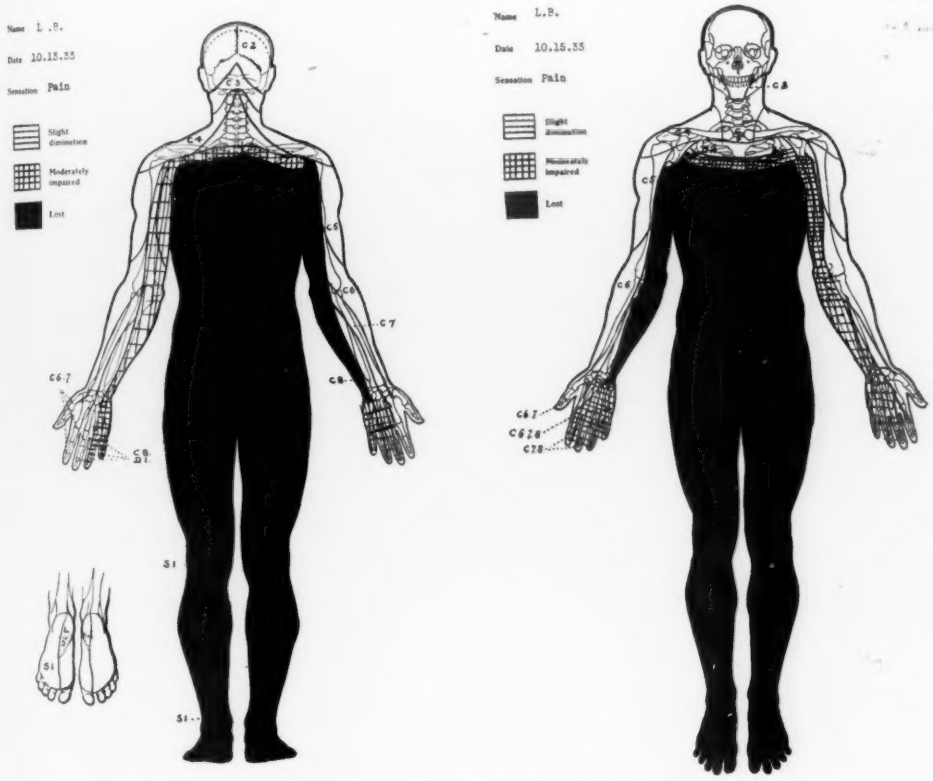

FIG. 4.—(Case II.) Pain sensation on second admission.

was reopened and additional laminae, T 1 and T 2, removed. At the level of the seventh spinal cord segment, the enlarged cord was found to be adherent to the dura mater. Through a fine needle, fluid was again evacuated from this area and a median incision was made into the intramedullary cavity. On this occasion, the cyst was found to measure 3½ cm. in length. A small piece of gutta percha was inserted for drainage and secured to the edge of the incision with one silver clip.

Course Following Second Operation.—October, 1933, to December, 1934.—The postoperative improvement of the patient was again gratifyingly rapid and within a month he was able to return to his previous occupation. At the last examination (ten months after the second operation), the only positive neurologic findings were: (1) Slight weakness (about 10 to 20 per cent loss of power) in the legs; (2) mildly hyperactive tendon reflexes in the lower extremities, and (3) slight impairment of pain and tempera-

ture sensation in the left hand (Fig. 5). The last letter from the patient (one year and one month postoperatively) stated that he is now married, and has resumed his former calling as a physical director. Subjectively he is perfectly well.

COMMENT.—The clinical course in this case was unusually irregular. The patient suffered frequent rapidly developing attacks of pain and weakness of various extremities, with spontaneous returns to normal over periods of a few weeks or months. These marked remissions, so pronounced as to suggest multiple sclerosis, are difficult to explain on the basis of the findings at

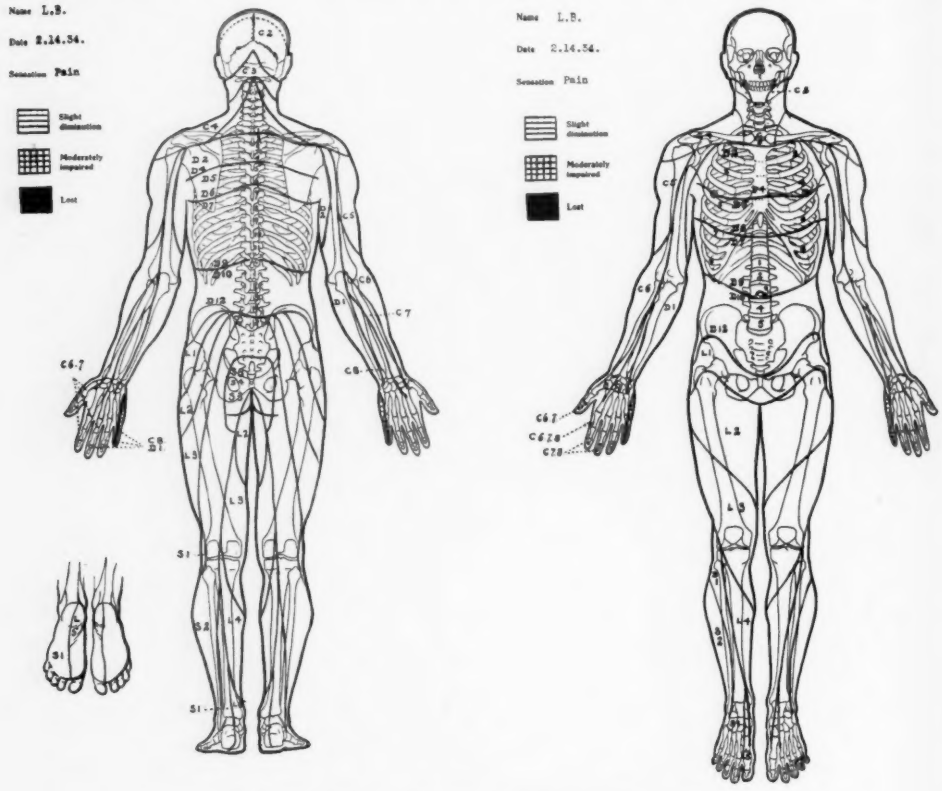

FIG. 5.—(Case II.) Pain sensation after second operation.

the first operation, unless it be assumed that pressure in the intramedullary cavity increased or that the cord became edematous at the times of the relapses.

The pathologic features of this case are of interest. From the course of the disease it seems quite certain that the lesion was syringomyelia and not, as assumed at the first operation, intramedullary glioma. Nevertheless, the evident gliosis, as seen at the first operation, leads us to postulate that this process may well be the predominant early pathologic feature in some cases of syringomyelia. These observations may be offered as evidence against the theory that the sequence of events in the progress of syringomyelia is (first) cavity formation, and (second) a reactive glial proliferation about the cavity.

Finally, the unexpectedly good results following both operations in this patient are worthy of comment. The improvement after the first laminectomy may perhaps be ascribed to the decompressive effects of leaving the dura unsutured and suggests that such a procedure may be the best method of dealing with cases of syringomyelia in this stage. But the improvement after the second intervention must be attributed to drainage of the syringomyelic cavity, and leads us to the conclusion that, even in the presence of an extensive gliosis, pressure in the intramedullary cyst may be the more important cause of loss of function.

TREATMENT.—During the past 30 years, two methods of therapeutic attack upon syringomyelia have been developed: (1) Irradiation, and (2) surgical drainage. Since Raymond,[16] in 1905, described the improvement in a case treated by roentgen rays, a considerable number of workers have reported upon the use of roentgen therapy. The majority of these writers have obtained favorable results in a certain percentage of cases. The statistics presented in one of the best of the recent papers (Markow, *et al.*[2]), summarizing the studies of 32 patients seen during four years, are representative. In this group, eight cases showed definite improvement, seven cases remained stationary for a "long" period, and 12 for four to five months; and five progressed during the treatment. It is important to remember that irradiation is considered to affect only the gliosis, and consequently is of little value in the presence of cavitation. This may be the explanation of the rather poor results of roentgen therapy in many instances. In this clinic, for example, we have never seen more than very transitory results for the use of irradiation.

In 1916, Elsberg[3] reported that several patients suffering with syringomyelia had been greatly benefited by laminectomy and incision into the syringomyelic cavity within the cord. In 1926, Puusepp[4] reported the same operation without knowledge of Elsberg's previous cases. Since this date, the surgical treatment of the disease has become well recognized throughout the world and nearly 100 cases have been reported.

Since the surgical attack is directed toward the syringomyelic cavity, and the roentgen ray is effective only in dealing with gliosis, it is possible that a combination of the two methods may ultimately prove to be the best method of dealing with the disease.

THE TECHNIC OF OPERATION.—The technic of the operation for syringomyelia has varied in the hands of different operators more widely than might be expected. The location of the incision, both as to level and on the circumference of the cord, the value of drainage of the cyst without laminectomy, the length of the cord incision, the means of determining the extent of the process, the material used for drainage, and the closure or nonclosure of the dura mater—all are problems of technic that ultimately may affect the results.

(1) *The Location of the Incision.*—It has been suggested (Schaeffer[5]) that the opening into the spinal cord should be at the inferior or lower end of the syringomyelic cavity to provide the best drainage. The very valid and

logical theoretical answer to this recommendation is the statement of Peiper[6] that the opening between the syringomyelic cavity and the subarachnoid space merely brings the pressures in the two fluid filled spaces into equilibrium. From a practical standpoint, moreover, excellent results have followed drainage at the level of greatest diameter of the intramedullary cyst rather than at its most dependent level.

Whether the incision should be mesial or lateral cannot be determined preoperatively on theoretical grounds. The majority of surgeons make the incision in the midline or just to one side of the midline. Because the cystic cavity in many cases lies more anteriorly than posteriorly, Oppel[15] maintained that an anterolateral incision was the safest and the most logical. His experiences with this plan were not encouraging, however, and it has not been adopted by others. Furthermore, Schmieden[7] pointed out that in some cases (as in one of his), the anterolateral approach may be extremely difficult, if not impossible, because of the marked enlargement of the spinal cord.

(2) *Drainage of the Cavity Through a Needle.*—Drainage of a syringomyelic cavity by direct puncture without laminectomy has been advocated by Vitek[8, 9] and others. Vitek merely reported improvement in four patients following this procedure, but further details are not available. Most writers have been either dubious or strongly opposed to this technic, although Puusepp[10] and others have used it for the injection of lipiodol into the intramedullary cavity as an aid in diagnosis. In Case I of our series, an exploratory needle was used to determine whether the cyst had refilled and a second operation was justifiable. Not only did the myelo-puncture demonstrate that the cavity had refilled, but in the improvement which followed clearly justified a second operation.

(3) *The Maintenance of Drainage.*—How best to maintain drainage is still a mooted question. The available data are meager. Christophe[11] found his incision still patent one month after he had made an opening into a cystic glioma. Ssosson-Jaroewitsch,[12] on the other hand, found no trace of his previous operation when he performed a second laminectomy on one of his syringomyelia patients.

In both of our cases, two operations were performed. Not a trace of the first incision was found in either patient, although in Case I a gutta percha drain had been used at the first operation. There can be no doubt, therefore, that in some instances, as the result either of arachnoid adhesions or wound closure by gliosis, the operative incisions do close. Whether this is true in all or in a majority of cases cannot yet be stated. The presumption that some such healing process does occur has led to the use of various measures aimed at insuring permanent drainage. Thus, Sharpe used silk thread; Mucenicks, dura mater; Peiper, excision of a window of cord tissue; Schaeffer, muscle; Gardner, silver clips about the margin of the incision; and Frazier, gutta percha secured in place with a silver clip.

Since there has been no observation after the use of any of these (except the gutta percha in our first case) the preference for one or the other material

is still an open question. On theoretical grounds, a foreign non-absorbable material should give greater assurance against closure of the incision, though it might prove more irritating.

(4) *Exploration and Visualization of the Cavity.*—Many surgeons use a sound or ureteral catheter to explore and determine the size of the cavity. Others have decried this practice. Still others have injected a few minims of lipiodol into the cavity at the operation (or by a needle before operation) to visualize the process in the roentgenographic films. To measure the length of the cavity we prefer a ureteral catheter; it is easy of manipulation and non-traumatizing; thus the irritating effect of lipiodol is avoided. As Juzelevsky[13] has pointed out, the danger of damaging the spinal cord by sounding the cavity is minimized because of its glial wall.

(5) *Closure of the Dura Mater.*—If the drainage incision remains patent, there seems to be no need for the decompressive effect obtained by leaving the dura mater unsutured. If the incision into the cavity closes, the subsequent expansion of the cord will cause compression eventually, even though the dura is not sutured. Consequently, there seems to be no reason for this measure unless the lesion is one chiefly of gliosis with little or no cavity formation, as was the situation in our second case.

(6) *Repeated Operations.*—From the data available at present, it is certain that some of the failures of operation for syringomyelia are the result of closure of the artificial communication established between the intramedullary cavity and the subarachnoid space. When this occurs, a second operation seems more than justified. If the decision is difficult (Case I) a trial of the effects of drainage by needle should determine the issue. The patient may fail to improve after the first operation but gain rapidly after the drainage of a second cyst. Mucenicks[14] and Oppel[15] have both reported this experience. In general, then, it may be concluded that in many cases with improvement following operation and subsequent relapse the patient may obtain great benefit from a second intervention.

The Late Results of Operation.—The results of surgery in 16 cases of syringomyelia in which an observation one year or more postoperatively was reported is presented in Table I, and summarized in Table III.

An analysis of the late results of surgery in the treatment of syringomyelia is difficult not only because of the variability and complexity of the cases, but because of the lack of detail in a number of the available reports. Nevertheless, as is shown in Table I, some grouping of the cases on the basis of results is possible. Group I, Table I, comprising those patients in whom the least improvement occurred following operation, includes three cases. Two of these patients (Nos. 1 and 2, Table I) were unchanged after operation, although it is to be noted that one of them was thought to have been benefited to the extent that a rapid downhill course was arrested for at least one year. One additional patient (No. 3), while profiting greatly from the return of sphincter control and the relief of pain and bulbar symptoms, showed relatively little improvement in motor or sensory function. At the other extreme, are the results in

TABLE I

	Case No.	Operator (Author)	Date Operated On	Duration in Years	Sex and Age	Size of Cavity	Site of Incision	Drain Used	Follow Up. Years	Late Result	Remarks	Group Result
Group I	1	Putnam and Munro	1926	5	M. 55	?	Midline	None	1.5	No change	2 swellings	Very little change
	2	Kirschner (Ellmer)	1930	1.5	M. 25	?	Midline	Muscle	1	No change	Rapidly progressive	
	3	Frazier-Rowe (1)	1930	15	F. 35	?	Right dorsolateral	Gutta-percha	4.5	Relieved incontinence and bulbar symptoms	Bulbar symptoms beginning to recur	
		Case 1 (2)	1933				Same	Same	2			
Group II	4	Elsberg Case 1	1914?	"Several"			Dorsolateral	None	2?	Improved		Moderate improvement
	5	Sharpe	1917		M.	5 cm.	Midline	Linen thread	2	Walked. Arms improved	Stationary in 1 year	
	6	Puusepp Case 2	1926	3	M. 25		Dorsolateral	None	7	Improved		
	7	Mucenicks (1)	1931	6	F. 40	4 cm.	Midline cervical	Dura mater	1.5	Improved after second operation		
		(2)	1931			5 cm.	Midline lumbar		1.2			
	8	Schmieden	1929	13	F. 30	16 cm.	Left dorsolateral	None	2.5	Improved	Last seen by Peiper	
Group III	9	Elsberg Case 2	1914	"Several"	M.		Dorsolateral	None	2?	Returned to work	Occupation, tailor	Marked improvement; returned to former occupation
	10	Puusepp Case 1	1926	1	M. 23	3 cm.	Dorsolateral	None	7	Walks normally Hands improved	Slight sensory loss	
	11	Puusepp Case 3	1927	5	M. 60	22 cm.	Dorsolateral	None	2	Returned to work		
	12	Puusepp Case 4	1927	4	M. 23	8 cm.	Midline?	None	7	Returned to work	Occupation, farmer	
	13	Puusepp Case 5	1927	.66	M. 37	17 cm.	Dorsolateral	None	4	Almost normal	Slight sensory loss	
	14	Foerster	1929		M.		Dorsolateral	None	2	Almost normal	Hydromyelia?	
	15	Heyman	1923	13	M.		"Posterior"	None	7	Able to work	Secretary	
	16	Frazier-Rowe (1)	1933	4	M. 27	3.5 cm.	Midline	None	2	Improved 6–7 mos.	Athletic teacher	
		(2)	1933				Midline	Gutta percha	1	Almost normal		

seven patients (Group III, Table I, Nos. 9 to 16, inclusive) who were able to return to their occupations after operation, three of them (Nos. 13, 14 and 16) being almost entirely well. The remaining six cases (Group II, Table I, Nos. 4 to 8, inclusive) fall into an intermediate group characterized by varying but incomplete degrees of recovery.

Do these results justify surgical drainage in the treatment of syringomyelia? That in 50 per cent of this series the improvement was sufficient to permit the patient to work, an improvement maintained from one to seven years, seems to us to more than counterbalance the possible dangers or possible failures of operation. It is of interest to note, too, that among the failures of this series no patient was the worse for the surgical undertaking.

It has been suggested that the results of the surgical treatment of syringomyelia bear some relation to the duration and the extent of the lesion. In reviewing the late results, we will attempt to determine the relative importance of these and such other factors as are believed to influence the clinical course after operation. Of these factors, presumably the most important are: (1) The sex and age of the patient; (2) the duration of symptoms; (3) the extent of the disease process; and (4) the operative technic employed. It may be that in any one case the result depends upon a combination of these factors. But, in addition, one must take into consideration unknown variations in the pathologic process.

In the 16 cases included in our analysis, the sex and age seem unimportant. It so happens that most of the patients were males. The range of known ages was 25 to 55 in Group I, 23 to 40 in Group II, and 27 to 60 in Group III.

The preoperative duration of symptoms in these three groups is shown in Table II. While indicating that, in general, poorer results are to be expected from operations on patients who have had symptoms more than seven years, the analysis of the cases in Table II is surprising in two respects: first, because excellent results were obtained in patients with an average duration of symptoms of over five years, and secondly, because one of these had had symptoms for 13 years.

TABLE II

PREOPERATIVE DURATION OF SYMPTOMS

Group	Number of Cases	Results	Shortest Duration	Longest Duration	Average Duration
I.....	3	Poorest	1.5 yrs.	15 yrs.	7 yrs.
II.....	6	Intermediate	.66 yrs.	13 yrs.	3.9 yrs.
III.....	7	Best	.66 yrs.	13 yrs.	4.9 yrs.

The third factor, which might influence the postoperative course, is the extent of the process as indicated by the clinical picture and by the character of the lesion as seen at operation. In Group I, the clinical pictures vary from moderate to very severe, and the processes, as viewed and described by the surgeon, similarly were variable. In these cases, the exact size of the cavities is not known, but presumably in most cases the cavities were larger. On the

TABLE III

SUMMARY OF SIXTEEN CASES WITH POSTOPERATIVE PERIODS OF OBSERVATION OF ONE YEAR OR MORE

	Case No.	Operator (Author)	Date Operated On	Duration in Years	Sex and Age	Motor Symptoms	Sensory Symptoms	Atrophy	Size of Cavity	Site of Incision	Drain Used	Follow Up. Years	Late Result	Remarks	Group Result
Group I	1	Putnam and Munro	1926	5	M. 55	Paresis of left arm	All forms impaired T 1 down	Left arm		Midline	None	1.5	No change	2 swellings	Very little change
	2	Kirschner (Ellmer)	1929	1.5	M. 25	Paresis both hands. Left worse	Impaired pain and touch in hands	Hands		Midline	Muscle	1	No change	Rapidly progressive	
	3	Frazier-Rowe (1)	1930	15	F. 35	Paralysis left arm Paresis legs, right arm	Loss C 2 down and impaired pain in face	All extremities Worse left		Right dorsolateral	Guttapercha	4.5	Relieved incontinence and bulbar symptoms	Bulbar symptoms beginning to recur	
		Case 1 (2)	1933			Quadriplegia	Same as above	Worse		Same	Same	2			
Group II	4	Elsberg Case 1	1914?	"Several"						Dorsolateral	None	2?	Improved		Moderate improvement
	5	Sharpe	1917		M.	Spastic paraplegia. Flac. paral. arms	"Dissociated sensory disturbance"		5 cm.	Midline	Linen thread	2	Walked. Arms improved	Stationary in 1 year	
	6	Puusepp Case 2	1926	3	M. 25	Paresis hands Slight paresis legs	Loss pain and touch C 5 to T 6	Arms		Dorsolateral	None	7	Improved		
	7	Mucenicks (1)	1931	.6	F. 40	Paresis legs and left arm	Slight impairment pain and touch, legs		4 cm.	Midline cervical	Dura mater	1.5	Improved after second operation		
		(2)	1931			Same	Same		5 cm.	Midline lumbar		1.2			
	8	Schmieden	1929	13	F. 30	Paresis left arm and leg Slight paresis right arm	Impaired pain right half body		16 cm.	Left dorsolateral	None	2.5	Improved	Last seen by Peiper	

	9	Elsberg Case 2	1914?	"Several"	M.					Dorsolateral	None	2?	Returned to work	Occupation, tailor	
	10	Puusepp Case 1	1926	1	M.	23	Paresis left hand Slight paresis right hand	Loss pain over neck, arms	Hands	3 cm.	Dorsolateral	None	7	Walk normally. Hands improved	Slight sensory loss	
	11	Puusepp Case 3	1927	5	M.	60	Paresis right arm and leg	Loss pain over right half body, face	Right extremities	22 cm.	Dorsolateral	None	2	Returned to work		
	12	Puusepp Case 4	1927	4	M.	23	Paresis arms, hands and slight legs	Pain impaired in upper extremities	Upper extremities	8 cm.	Midline?	None	7	Returned to work	Occupation, farmer	Marked improvement; returned to occupation
Group III	13	Puusepp Case 5	1927	.66	M.	37	Spastic paraplegia Paresis right arm	Loss pain over right ½ body and face	Right arm	17 cm.	Dorsolateral	None	4	Almost normal	Slight sensory loss	
	14	Foerster	1927		M.		Paresis both arms and both legs	Disturbance sensory C 1–T 3 and left face	Atrophy arms		Dorsolateral	None	2	Almost normal	Hydromyelia?	
	15	Heyman	1923	13	M.						"Posterior"	None	7	Able to work	Secretary	
	16	Frazier-Rowe (1)	1933	4	M.	27	Spastic paraplegia Paresis both arms	Loss pain C 8, D 4–D 12, and legs and hands	Forearms		Midline	None	2	Improved 6–7 mos.		
		Case 2 (2)	1933				Same	Nearly same	Arms	3.5 cm.	Midline	Gutta percha	1.1	Almost normal	Athletic coach	

other hand, among the patients with the best results (Group III) the clinical pictures again varied from moderate to very severe, with cyst cavities which were known to range from 4 to 16 cm. in length. It is plain that in this series, at least, the late results do not show as close a correlation with the preoperative extent of the process as might be expected. It is possible, of course, that the discrepancy will become less marked in the future with the addition of more cases and improvement and standardization of operative methods.

The remaining important source of variation in the results is the operative technic. Suffice it to say here that since the correlation between other variable factors in each case and the extent of the postoperative improvement of the patient is so uncertain, it would seem reasonable to regard the surgical technic employed as highly important.

It is evident, then, that the factors controlling the results are not entirely understood, and probably are pathologic as well as clinical. It does seem possible that the operative technic may be important, but age, duration and the extent of the disease do not at present seem closely related to the ultimate improvement. The careful observation of the extent and character of the pathology at operation as well as at autopsy in more cases will doubtless lead to a clearer solution of these problems. At present, in spite of the difficulties of predicting the exact results of operation preoperatively, two facts seem certain: (1) The majority of the reported operated patients who have been followed for more than one year have been benefited, and (2) none of this group has been made worse by the surgical intervention.

SUMMARY

(1) Two cases of syringomyelia are recorded in which surgical treatment resulted in improvement over periods of four and one-half and two years, respectively.

(2) Fourteen additional cases from other clinics, whose period of postoperative observation was one year or more, have been analyzed. A review of the results in 16 cases shows that half of them (eight patients) were sufficiently improved to return to their former occupations.

(3) Sex, age, the extent of the process or the preoperative clinical picture seemed to have little bearing upon the operative results. Probably the duration of the disease and the technic employed, to a certain extent, may influence the end-results.

(4) A judicial review of the various technics employed suggests that: (*a*) A vertical cordotomy in the midline posteriorly or a few Mm. lateral to it on the side of the greatest cord damage (as evidenced by the clinical picture) is the most efficacious and the least dangerous approach to the syringomyelic cavity. (*b*) An attempt at establishing permanent drainage by the use of drainage material seems worth while. (*c*) If, after the initial drainage, the clinical course suggests a closure of the incision into the syringomyelic cavity, a second operation is indicated.

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DISCUSSION.—DR. WILLIAM JASON MIXTER (Boston, Mass.): I am very much interested in syringomyelia and feel that our experience in Boston has been similar to that of Doctor Frazier in many ways. We have also been discouraged with the result of simple incision of these cystic cavities, and have wondered whether some means of permanent drainage might be carried out. Some patients improve under roentgen ray therapy but it is difficult to measure the extent of improvement and unsatisfactory because any improvement gained is frequently temporary. Eighteen cases have been operated upon since 1919 by opening the cavity, and one of them at least had repeated operations of that sort. Some of these patients who have been operated upon have gone back to work for a short time, but all have had a recurrence of symptoms.

During the last eight months, I have operated upon two cases, using a slightly different method from that which Doctor Frazier has suggested. In these two cases, the cavity was opened longitudinally and the lining membrane of the cavity was sutured to the arachnoid at each side, thus forming a lozenge shaped opening which I hope will remain permanent, though I have no proof that such will be the case. Both of these patients have improved markedly and have gone back to work, though one of them is still greatly handicapped. Neither of them has been of sufficiently long duration to give us any idea as to the permanency of the result.

COMPLETE SYMPATHECTOMY

OBSERVATIONS OF CERTAIN VASCULAR REACTIONS DURING AND AFTER COMPLETE EXCLUSION OF THE SYMPATHETIC NERVOUS SYSTEM IN DOGS *

AN EXPERIMENTAL STUDY

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CANNON and his coworkers[1] showed that animals subjected to complete extirpation of both sympathetic nerve chains could live indefinitely under controlled laboratory conditions, but thought that such animals were unable to cope normally with changes in their environment. Subsequently, other workers,[2, 3] have used Cannon's technic to study the physiology of the sympathetics, and Bradford Cannon[4] has described observations on the blood pressure changes resulting from the various stages of complete sympathectomy.

The present experiments were undertaken in an effort to investigate further the relationship of the sympathetic nervous system to the blood pressure. It was especially desired to study the factors concerned in the causation of lowered blood pressures in relation to traumatic shock. Roome, Keith, and Phemister[5] described experiments in which the blood pressure was reduced by various methods, and the circulating blood volume estimated by bleeding; certain similar studies will be described on completely sympathectomized animals.

EXPERIMENTAL METHODS

Method of Preparation of Animals.—Dogs were used in all experiments. Complete extirpation of the sympathetic chains was carried out in three stages, from 10 to 21 days intervening between operations. All operations were under ether anesthesia, with positive pressure when the chest was to be opened.

The right thoracic sympathetic chain was first removed from above the stellate ganglion to the diaphragm; secondly, the left thoracic chain was similarly removed; and lastly, both abdominal chains were excised from the diaphragm to a point in the pelvis 1 to 2 cm. below the sacral promontory. The completeness of the sympathectomy was checked in each animal at the time it was sacrificed by careful search for remaining portions of the chain. In two dogs a single ganglion was found at the diaphragm on the left side; the left splanchnic, however, was found sectioned in every dog. Although technical difficulties prevented removal of the lower sacral sympathetic chains, these remaining ganglia receive their preganglionic fibers from or through proximal ganglia surgically removed and were thus separated

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from the central nervous system. The term "complete sympathectomy" refers in this paper to this complete isolation of the peripheral sympathetic nerves from the central nervous system.

EXPERIMENTS

I. The Blood Pressure Changes During and After Progressive Sympathectomy

In 1931 Cannon[4] described the blood pressure changes occurring after the various stages of total sympathectomy in dogs. The order in which Cannon removed the various segments of the system differs from that of the present experiments; he first removed both abdominal chains, then the right thoracic, and lastly the left thoracic. The blood pressure in his experiments was measured indirectly, and was found to fall immediately after each operation. Following this depression, there was after the first two stages a marked rise of the pressure above the control level, which persisted over a period of several days and then gradually tended to return to the control level. After the final operation the blood pressure fell lower than at any time previously and then rose to nearly the control level.

In the present experiments the blood pressure was recorded on a kymograph by the direct method of arterial puncture with a 20 gauge needle, connected to a mercury manometer.

A. Control Experiments.—(a) Four dogs were merely kept caged in the laboratory for three months, and the blood pressure recorded as described every three to ten days. The maximum range of variation observed during this period was 25 Mm./Hg. and the maximum depression from the original readings at the end of the period was 10 Mm./Hg.

(b) Two dogs were subjected to dummy operations similar to the three stages of complete sympathectomy. These operations consisted of: (1) opening the right pleural cavity, and scarifying the pleura parallel to the entire right thoracic chain; (2) after an interval of 10 to 14 days, a similar procedure in the left chest, and (3) finally a laparotomy, with considerable exploration and manipulation. The blood pressure was recorded as described, and in both dogs was found to remain within 15 Mm./Hg. of the initial readings.

B. Experiments During and After Sympathectomy.—In 13 dogs the blood pressure was recorded at frequent intervals during the course of complete sympathectomy and for 9 to 27 days after the final stage.

There was observed a sharp depression of the blood pressure of from 15 to 50 Mm./Hg. on the day following each operation, the least fall usually occurring after the third stage and the greatest fall after removal of the left thoracic chain (second stage), at which time the left splanchnic nerve was sectioned at the diaphragm. After the first operation the pressure returned to the control level or slightly above in six dogs (the maximum rise above the control level being 15 Mm./Hg.) within a week, while in the remaining seven dogs the blood pressure was still 15 to 25 Mm./Hg. below the control level at the end of two to three weeks.

One week after the final operation the average of the blood pressures was 36 Mm./Hg. below the control level, and two to three weeks after the final stage the average was 30 Mm./Hg. below the normal average (Table I). Three typical blood pressure curves during progressive sympathectomy and one dummy curve are given in Charts 1 and 2. It was found that the blood pressure gradually returned to normal

over a period of months; further observations on this subject are to be published in a later paper (Grimson).

TABLE I

THE BLOOD PRESSURE OF COMPLETELY SYMPATHECTOMIZED DOGS

Dog No.	Initial blood pressure, Mm./Hg.	Blood pressure one week after final stage of sympathectomy, Mm./Hg.	Blood pressure two to three weeks after final stage of sympathectomy, Mm./Hg.
241	128	112	120
290	156	107	101
293	160	120	123
294	127	102	100
308	143	113	135
356	145	118	104
374	126	112	110
406	145	106	106
407	130	84	...
408	163	115	122
470	140	100	110
507	165	108	116
654	130	90	108
Average of 13 dogs...	143	106.7	113

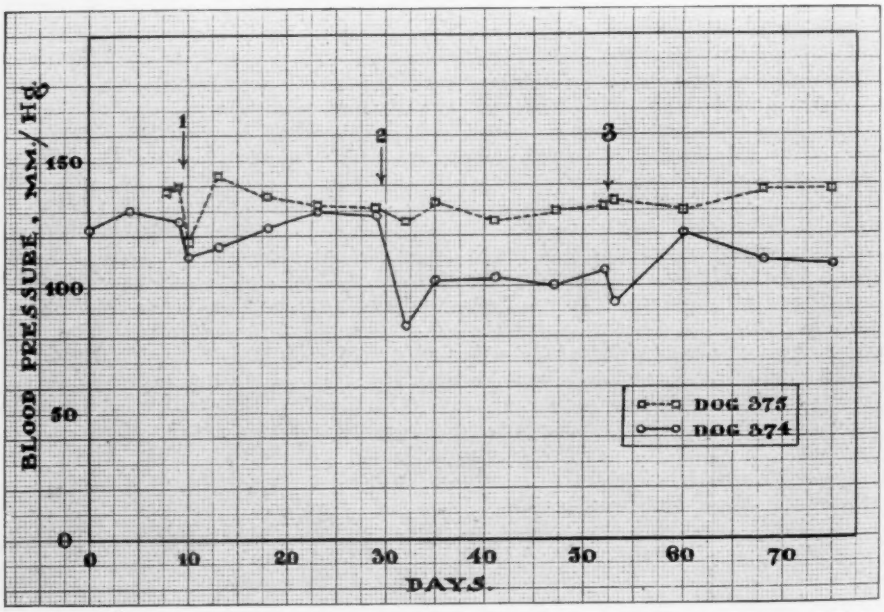

CHART 1.—Blood pressure changes resulting from three stages of complete sympathectomy (dog 374) compared with the effects of three dummy operations (dog 375) at similar intervals. The numerals 1, 2 and 3 indicate the day of the operation.

II. Effects of High Spinal Anesthesia on the Blood Pressure

It is well known that high spinal anesthesia results in a considerable fall in blood pressure, presumably by interference with conduction of vasoconstrictor impulses in the efferent spinal nerves in the dorsal region.

A. Control Experiments.—In six dogs sufficient novocain solution was injected intrathecally at the level of the second lumbar interspace to produce anesthesia usually to cervical segment levels. The mean blood pressure was recorded by a carotid

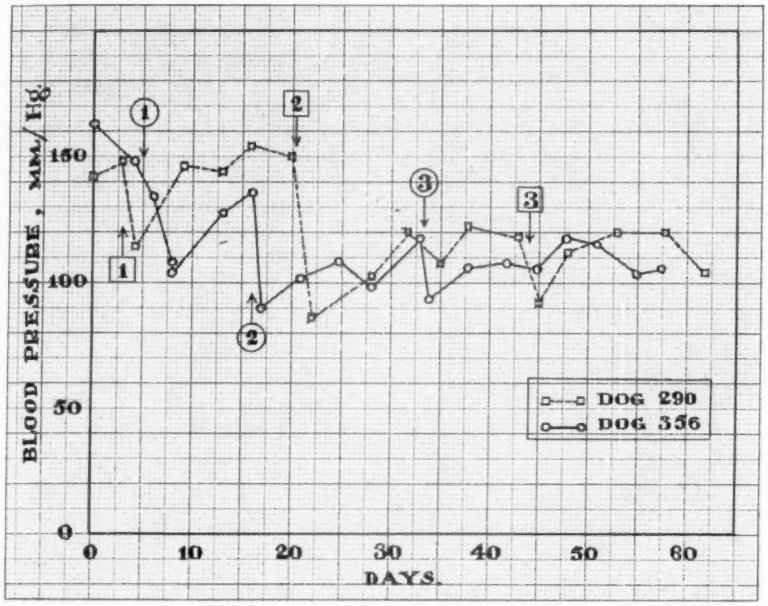

CHART 2.—Blood pressure changes resulting from complete sympathectomy in two dogs. The numerals indicate the day of operation.

cannula, mercury manometer and kymograph. In every instance a marked fall of the blood pressure occurred as the anesthesia extended upward. In one experiment respiratory failure occurred and mechanical artificial respiration was used. The control blood pressures ranged from 120 to 170 Mm./Hg.; after periods of from 45 to 91

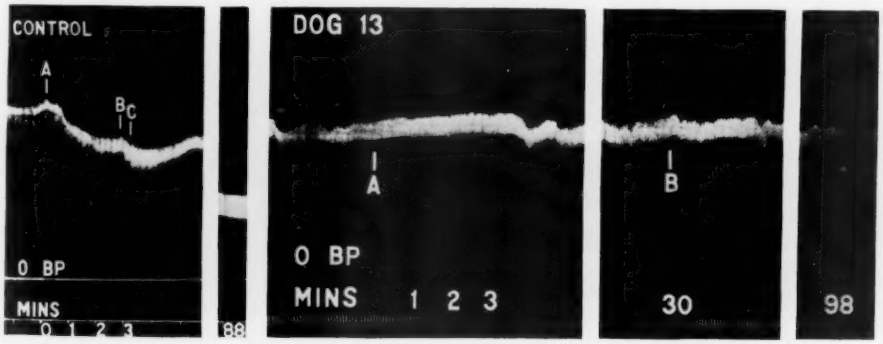

CHART 3.—Typical kymograph tracings of the effect on the blood pressure of high spinal anesthesia in a control dog and in a completely sympathectomized animal (dog 13). Novocain was injected intrathecally at points A and B in both tracings and the ether anesthesia was stopped at C on the control tracing.

minutes, the blood pressures were from 48 to 70 Mm./Hg. Depressions of from 58 to 120 Mm./Hg. had thus occurred as a result of the high spinal anesthesia.

B. Spinal Anesthesia in Completely Sympathectomized Dogs.—Four experiments were carried out in the same manner as described above, upon dogs from 13 to 32 days after complete sympathectomy. In one experiment both vagus nerves were sec-

tioned before giving the spinal anesthetic. In another case, mechanical artificial respiration was necessary for imminent respiratory failure. There was no marked fall of the blood pressure in any experiment during the period of observation, 45 to 98 minutes; the blood pressure rose 2 Mm./Hg. in one animal and fell from 5 to 20 Mm./Hg. in the remaining three dogs. The results of this series of experiments and of the control series are given in detail in Table II. A typical kymograph tracing of the blood pressure response as compared with the response in the normal animal is given in Chart 3.

TABLE II

EFFECTS OF HIGH SPINAL ANESTHESIA UPON THE BLOOD PRESSURE

Dog No.	Time of experiment, days after final stage of sympathectomy	Initial blood pressure, Mm./Hg.	Duration of experiment, mins.	Final blood pressure, Mm./Hg.	Blood pressure change, Mm./Hg.
		(A) Control Series, Normal Dogs			
305		170	50	50	minus 120
312		155	55	58	minus 97
313		138	45	48	minus 90
347		120	70	62	minus 58
385*		140	56	55	minus 85
417		154	91	70	minus 84
Average of six control dogs		146		57	minus 89
		(B) Completely Sympathectomized Dogs			
136	13	120	45	100	minus 20
137	15	88	60	83	minus 5
13†	27	98	98	100	plus 2
27*	32	130	60	112	minus 18
Average of four sympathectomized dogs		109		99	minus 10

* Mechanical artificial respiration used.

† Vagi sectioned before spinal anesthesia induced.

III. Effects of Section of the Cervical Spinal Cord on the Blood Pressure

A profound blood pressure fall results in normal animals when the spinal cord is sectioned at high levels. This effect may be due, as in spinal anesthesia, to the withdrawal of tonic vasoconstrictor impulses, passing down from the higher centers.

A. Control Experiments.—The spinal cord was sectioned under ether anesthesia in 24 normal dogs at the level of the seventh cervical or first thoracic vertebrae. In all cases a marked blood pressure fall occurred; the initial pressures varied from 70 to 158 Mm./Hg., and fell to levels of from 38 to 90 Mm./Hg. 11 to 74 minutes after division of the cord. In 12 of the 24 animals there was a marked but transient rise of the blood pressure immediately after cutting the cord, with its maximum 15 seconds to three minutes after section. This rise persisted two to three minutes, and was followed by a gradual decline of the blood pressure. The transient increase of the blood pressure

was thought due to vasoconstrictor stimulation by the cutting. Six examples of typical experiments from this series are given in summary in Section A, Table III.

TABLE III

EFFECTS OF SPINAL CORD SECTION UPON THE BLOOD PRESSURE

Dog No.	Time of experiment, days after final stage of sympathectomy	Initial blood pressure, Mm./Hg.	Time of maximum blood pressure, secs.	Maximum blood pressure, Mm./Hg.	Final blood pressure, Mm./Hg.	Time of final blood pressure, mins.	Change in blood pressure, Mm./Hg
(A) Control Experiments, Normal Dogs							
341		110	No rise		65	60	minus 45
420		117	No rise		46	65	minus 75
425		90	60	152	60	74	minus 30
436		149	15	233	90	47	minus 59
442		112	60	183	52	41	minus 60
443		138	No rise		63	40	minus 75
Average of six control dogs		119			62.7		minus 57
(B) Completely Sympathectomized Animals							
136	15	80	No rise		80	58	0
471		93	No rise		77		minus 16
137	21	90	No rise		90	60	0
117	50	82	No rise		80	60	minus 2
Average of four sympathectomized dogs		86			82		minus 4.5

B. Spinal Cord Section in Completely Sympathectomized Dogs.—The spinal cord was similarly cut in four completely sympathectomized dogs. In each case there was a slight depression of the blood pressure at the moment of section, but within two minutes it had returned to the former level, and with one exception remained at this

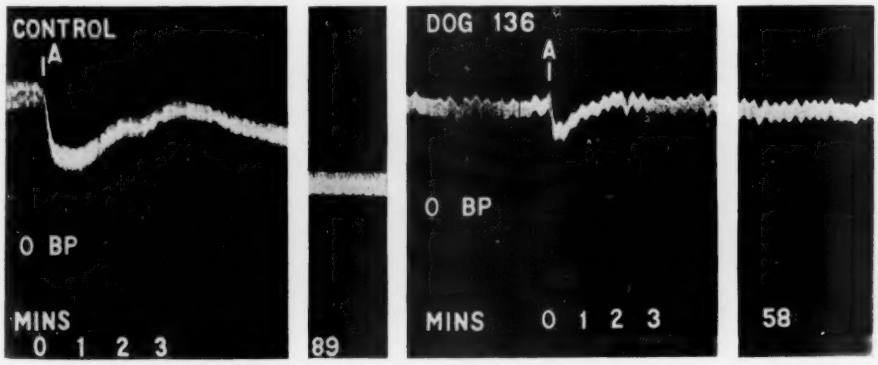

CHART 4.—Typical kymograph tracings of the effect on the blood pressure of cervical spinal cord section in a control dog and in a completely sympathectomized animal (dog 136). The spinal cord was sectioned at A. Note that the initial blood pressure of the sympathectomized animal is lower than that of the control, but the terminal blood pressure of the control dog is much lower than that of the sympathectomized animal.

level during the period of observation, from 45 to 60 minutes. In no case was there the temporary rise above the normal, as observed in half the control animals (Section B, Table III). Kymograph tracings of typical reactions in control dogs and sympathectomized dogs are given in Chart 4.

tioned before giving the spinal anesthetic. In another case, mechanical artificial respiration was necessary for imminent respiratory failure. There was no marked fall of the blood pressure in any experiment during the period of observation, 45 to 98 minutes; the blood pressure rose 2 Mm./Hg. in one animal and fell from 5 to 20 Mm./Hg. in the remaining three dogs. The results of this series of experiments and of the control series are given in detail in Table II. A typical kymograph tracing of the blood pressure response as compared with the response in the normal animal is given in Chart 3.

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436		149	15	233	90	47	minus 59
442		112	60	183	52	41	minus 60
443		138	No rise		63	40	minus 75
Average of six control dogs		119			62.7		minus 57
(B) Completely Sympathectomized Animals							
136	15	80	No rise		80	58	0
471		93	No rise		77		minus 16
137	21	90	No rise		90	60	0
117	50	82	No rise		80	60	minus 2
Average of four sympathectomized dogs		86			82		minus 4.5

B. Spinal Cord Section in Completely Sympathectomized Dogs.—The spinal cord was similarly cut in four completely sympathectomized dogs. In each case there was a slight depression of the blood pressure at the moment of section, but within two minutes it had returned to the former level, and with one exception remained at this

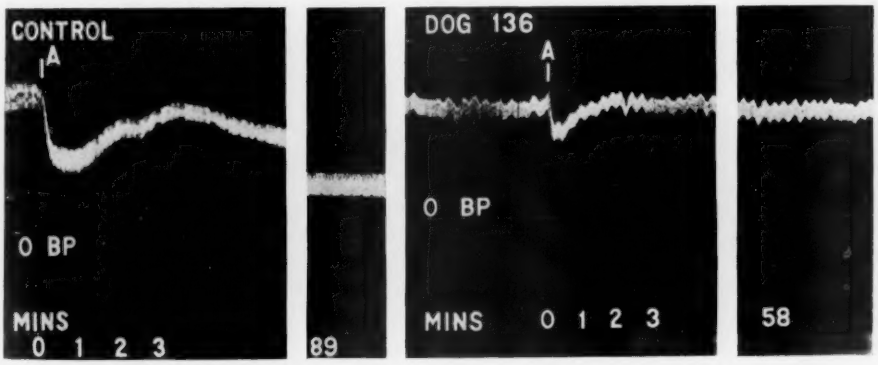

CHART 4.—Typical kymograph tracings of the effect on the blood pressure of cervical spinal cord section in a control dog and in a completely sympathectomized animal (dog 136). The spinal cord was sectioned at A. Note that the initial blood pressure of the sympathectomized animal is lower than that of the control, but the terminal blood pressure of the control dog is much lower than that of the sympathectomized animal.

level during the period of observation, from 45 to 60 minutes. In no case was there the temporary rise above the normal, as observed in half the control animals (Section B, Table III). Kymograph tracings of typical reactions in control dogs and sympathectomized dogs are given in Chart 4.

IV. Effects of Sciatic Nerve Stimulation upon the Blood Pressure

Electrical stimulation of the central end of the cut sciatic nerve results (in anesthetized dogs) in blood pressure changes which depend on the strength and frequency of the stimulus.[6] Strong faradic currents result in a rise of the blood pressure; weaker, and slowly interrupted shocks produce a fall.

A. Stimulation with Tetanizing Current.—In six dogs completely sympathectomized for 17 to 28 days the sciatic nerve was cut and its central end stimulated with 12 different strengths of tetanizing current from a Harvard inductorium, by means of a bipolar electrode. In no case was there a definite rise of the blood pressure; with the stronger stimuli there was marked hyperventilation, and this was occasionally accompanied by a slight fall of the blood pressure, probably due to acapnia. Control animals uniformly gave the pressor response with similar stimulation. Kymograph tracings of control and sympathectomized dogs are given in Chart 5. In other experiments, to be reported later, rises in blood pressure were observed in dogs sympathectomized for longer periods.

FIG. 5. FIG. 6.

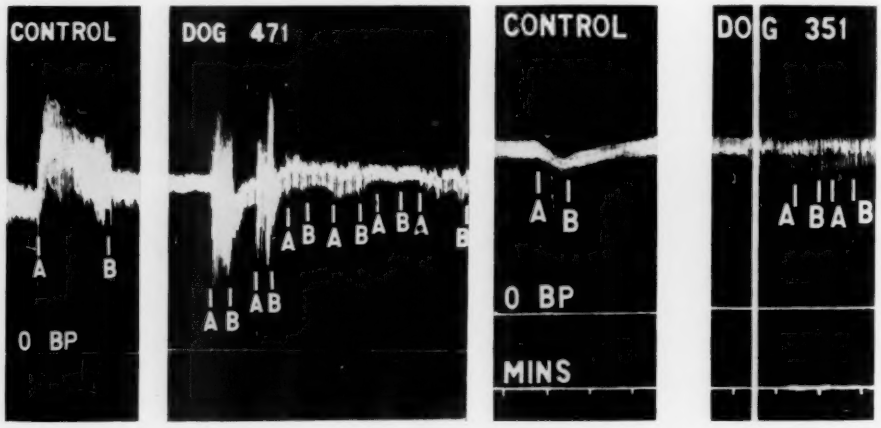

CHART 5.—Typical kymograph tracing showing the effect of stimulation of the central end of the cut sciatic nerve with various strengths of tetanizing current in a control dog and in a completely sympathectomized dog (dog 471). The stimulation was started at A and stopped at B in each case.

CHART 6.—Kymograph tracing showing the effect of stimulation of the central end of the cut sciatic nerve with slow make and break shocks, in a control dog and in a completely sympathectomized dog (dog 351). Stimulation was started at A and stopped at B in each case.

B. Stimulation by Weaker, Slower Shocks.—In four of the above animals the central end of the cut nerve was stimulated by weak make and break shocks of a frequency of about five per second. No depressor response was obtained. Four control animals uniformly responded to similar stimulation by a depression of the blood pressure (Chart 6).

V. Studies on the Bleeding Volume at "Normal" Blood Pressures

The bleeding volume has been used as an index of the circulating blood volume by various investigators.[6, 7]

A. Control Experiments.—Roome, Keith and Phemister[5] measured the bleeding volumes of a series of 20 normal dogs, under ether and under barbital anesthesia, in the following manner. The animal was bled to death in the horizontal position from a large cannula in a carotid artery which was kept free from obstructions; the amount bled

was described as a percentage of the blood volume calculated as 1/13 of the body weight. The average "bleeding volume" was found to be 58.6 per cent of the calculated blood volume (c.b.v.).

B. Bleeding Volumes of Completely Sympathectomized Dogs.—In five completely sympathectomized dogs the bleeding volume was measured as described, except that local anesthesia was used. The amounts obtained were from 39 to 55 per cent of the c.b.v., and averaged 49.4 per cent. This average is somewhat below the normal average, although the individual bleeding volumes fall within the normal range of variation. It must be noted, however, that the blood pressures of the sympathectomized dogs were in most cases subnormal (Table IV) and this factor must be considered in the interpretation of the results.

TABLE IV

BLEEDING VOLUMES OF COMPLETELY SYMPATHECTOMIZED DOGS

Dog No.	Time of experiment, days after final stage of sympathectomy	Blood pressure just before bleeding, Mm./Hg.	Amount bled, per cent of calculated blood volume
407	9	84	53.0
224	19	...	39.0
242	22	120	50.3
168	28	...	53.6
241	30	104	55.0
114	39	98	45.4
Average of six sympathectomized dogs		101.5	49.4
Average of 20 normal dogs (Roome, Keith and Phemister[5])		...	58.6

VI. Studies on the Bleeding Volume at Reduced Blood Pressures

A. Control Experiments.—The bleeding volumes of dogs after reduction of the blood pressure by various methods was studied by Roome, Keith and Phemister,[5] and these observations were used as controls for the present experiments. These authors found that the average bleeding volume of six dogs whose blood pressures were lowered to an average level of 54 Mm./Hg. by histamine administration was 50.5 per cent of the c.b.v., and that the average bleeding volume of seven dogs after graded hemorrhage, at average terminal blood pressures of 61 Mm./Hg., was 24.9 per cent of the c.b.v.

B. Experiments on Sympathectomized Animals.—Similar bleeding volume measurements were made on six completely sympathectomized dogs 19 to 41 days after the final stage of preparation. These experiments are summarized in Table V.

Three dogs were given an aqueous solution of histamine in repeated small subcutaneous and intramuscular injections in sufficient amounts to maintain the blood pressure at levels of from 40 to 70 Mm./Hg. over a period of from 45 to 50 minutes. The amounts bled at the end of this period were from 42 to 53 per cent of the c.b.v., and averaged 48.1 per cent of the c.b.v., a figure not significantly lower than the average of the control series (50.5 per cent) (Table V, Section I).

Three other completely sympathectomized dogs were gradually bled small amounts from a carotid artery, until the blood pressure remained at levels of from 55 to 70 Mm./Hg. The bleeding volumes of these animals 55 to 78 minutes after the beginning of the

TABLE V

BLEEDING VOLUMES AFTER REDUCTION OF THE BLOOD PRESSURE

Dog No.	Time of experiment, days after final stage of sympathectomy	Initial blood pressure, Mm./Hg.	Final blood pressure, Mm./Hg.	Amount of blood or plasma removed, per cent of c.b.v.	Terminal bleeding volume, per cent of c.b.v.	Duration of experiment, mins.
(A) Blood Pressure Lowered by Histamine Administration						
356	17	106	40	..	42	50
353	24	90	50	..	53	45
351	26	100	60	..	49.2	50
Average of three sympathectomized dogs					48.1	
Average of six control dogs (Roome, Keith and Phemister[5])					50.5	
(B) Blood Pressure Lowered by Graded Hemorrhage						
470	19	106	60	39	25.5	70
294	27	104	70	30	28	55
422	41	100	55	30	16	78
Average of three sympathectomized dogs				33	23.2	
Average of seven control dogs (same source)				45.5	24.9	

experiment was from 16 to 28 per cent of the c.b.v. and averaged 23.2 per cent. This figure is very close to the average bleeding volume of the control dogs, 24.9 per cent.

DISCUSSION.—The observations described above upon the blood pressure of dogs during the three stages of complete sympathetic exclusion have confirmed Cannon's finding that the blood pressures tend to recover after each stage of the sympathectomy. However, they do not confirm the existence of a marked overcompensation, *i.e.*, there was no significant rise of blood pressure above the normal. After the right thoracic chain was removed half the animals maintained a blood pressure very slightly above normal and one-half fell below, but all of the readings, except on the first postoperative day, were within the normal range. Following removal of the left thoracic chain with section of the greater splanchnic nerve the greatest and most continued depression occurred. The abdominal sympathectomy usually produced no significant change in the blood pressure. The disagreement with Cannon's observations may be due to the different order in which the stages of sympathectomy were carried out in his and in the present experiments.

Further investigation is necessary to evaluate the relative importance of the portions of the sympathetic chain in the production of lowered blood pressure. Six of the animals described have been kept for periods of many months and all have shown blood pressure recovery that casts doubt on the idea of maintained hypotension following any type of sympathetic surgery. It must be remembered, however, that in these experiments normal animals have been used, while the surgical procedures which have been described by various authors are directed toward lowering an abnormally high arterial tension.

In Series II and III of the experiments described it was observed that the blood pressure depression, which follows section of the cervical spinal cord, and high spinal anesthesia in normal dogs, was absent in recently completely sympathectomized ones. This finding agrees with the commonly accepted idea that the depressor effect of these two procedures is due to the removal of tonic vasoconstrictor impulses passing down the cord from the vasomotor center and leaving it by the thoracolumbar outflow. The transient rise of the blood pressure which may occur at the moment of section of the spinal cord of normal dogs was also absent in the sympathectomized animals observed; this is as would be expected if the rise is due to stimulation of vasoconstrictor fibers at the point of section. Both these observations suggest that in recently sympathectomized animals there is no important vasoconstrictor outflow from the spinal cord below the first dorsal segment, and that in the intact animal all such outflow is carried through the sympathetic chains. The transient blood pressure depression when the spinal cord is cut in the sympathectomized dog may be due to sudden complete relaxation of the entire musculature below the point of section with temporary impairment of the venous return to the heart.

Comparison of the blood pressure maintained shortly after sympathectomy (average for 13 dogs, 106.7 Mm./Hg. one week after the final stage) with the blood pressures resulting immediately from high spinal anesthesia and cervical cord section in normal dogs (average for 12 dogs, 59.9 Mm./Hg.) indicates the presence in the former condition of some factor maintaining the blood pressure at a higher level than in the latter conditions, although in all there is presumably nearly complete loss of vasomotor tone. The question arises, then, is there a compensatory increase in the circulating blood volume? Freeman[7] reported that a diminished blood volume may result from the continued vasoconstriction and high blood pressure produced by adrenalin. Does the reverse hold true for animals in which there is continued vasodilation? The bleeding volume of a series of completely sympathectomized dogs was found, however, to be slightly below the normal (Series V). When the reduced blood pressure is considered this finding seems to indicate that the circulating blood volume is very nearly normal, and certainly not increased. Hence some other factor than increased blood volume is responsible for the maintenance of the blood pressure after complete sympathectomy.

The bleeding volumes of completely sympathectomized dogs at reduced

blood pressures were also very nearly the same as in normal dogs under similar conditions (Series VI). Now, in the maintenance of the blood pressure after hemorrhage when the blood volume and viscosity are diminished, reflex vasoconstriction is an important factor in normal dogs. Thus, the circulating volume can be markedly reduced by hemorrhage before much fall of the blood pressure occurs, and even at reduced pressures of 50 to 70 Mm./Hg., the bleeding volume is found reduced to a less percentage than the blood pressure (Roome, Keith and Phemister[5]). The great similarity of the bleeding volumes of normal and recently sympathectomized animals with lowered pressures suggests that there is some vasoconstrictor mechanism effective shortly after removal of the sympathetic chains. Since there is no effect on the blood pressure from cervical spinal cord section or from spinal anesthesia it would seem that this mechanism is entirely peripheral and thus due to hormone or intrinsic vasomotor control.

The experiments (Series IV) in which blood pressure changes were not found to occur with electrical stimulation of the cut sciatic nerve seem to simply show that the reflex arc concerned is interrupted.

The fact that in the sympathectomized animals with lowered blood pressures, the bleeding volumes were approximately normal suggests that such animals should withstand hemorrhage, trauma, or an operation approximately as well as normal dogs. It must be noted that under laboratory conditions no obvious difference in general appearance or behavior follows complete sympathectomy.

SUMMARY.—Experiments are described on 27 dogs in which both sympathetic chains were resected by a three-stage technic. The blood pressure was measured by arterial puncture in 13 dogs, at intervals, between the various stages and for two to three weeks after the final operation. The effects of cervical spinal cord section, of spinal anesthesia, and of electrical stimulation of the central end of the cut sciatic nerve, were then tested. The bleeding volumes of completely sympathectomized dogs were measured at the slightly reduced blood pressures which occur after sympathectomy, and also after further reduction (to shock levels) by histamine and by bleeding.

CONCLUSIONS

(1) When the sympathetic chains are excised by the technic described, the blood pressure is lowered most extensively by the excision of the left thoracic sympathetic chain which includes a section of the greater splanchnic nerve, and no marked rise above the normal range of blood pressure occurs after any stage of the procedure.

(2) The circulating blood volume as estimated by the bleeding volume is not much altered and is certainly not increased after complete sympathectomy.

(3) The effects upon the bleeding volume of lowering the blood pressure by histamine or by hemorrhage are similar in completely sympathectomized dogs to the effects in normal dogs.

(4) The depressions of the blood pressure accompanying cervical spinal cord section, and high spinal anesthesia in the normal dog are absent in the recently sympathectomized animal.

(5) Electrical stimulation of the central end of the cut sciatic nerve produces no effect upon the blood pressure in recently sympathectomized dogs.

(6) The blood pressure after complete sympathectomy remains at a higher level than would be expected after withdrawal of all vasoconstrictor tone (*e.g.*, as by spinal anesthesia). The possibility of a peripheral vasoconstrictor mechanism is suggested.

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LUMBAR GANGLIONECTOMY AND TRUNK RESECTION IN CHRONIC ARTHRITIS*

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WE ARE all familiar with the results obtained by sympathetic ganglionectomy and trunk resection in vascular diseases of the extremities. Rowntree has suggested that lumbar ganglionectomy and trunk resection be tried in an instance of periarticular arthritis of the chronic type, accompanied by spastic vasomotor phenomena manifested by cold, clammy, pale, and occasionally cyanotic extremities.

The first patient was operated upon in June, 1926. The results were most gratifying.[1] Its use was confined to cases of chronic arthritis in which vasomotor spastic phenomena either preceded or accompanied the arthritis. In 1930, Rowntree[2] reported the results in 17 cases of chronic arthritis in which this procedure had been used. The operation was not employed unless the patients had been thoroughly studied, all foci of infection had been eradicated, all generally accepted medical measures had been used over a period of at least six months without improvement; and the patients reacted to the administration of typhoid vaccine intravenously with a high vascular index. In these 17 cases, the best results were obtained when the disease was confined to the hands and feet. When the knees and elbows were involved, the improvement was much less marked and slower in development. When the hip joints were involved, there was little or no improvement. In 1932, Henderson and Adson[3] reported the operative results in 41 cases. They divided their cases into three groups: Group I, in which the disease was most advanced and there were numerous ankylosed joints. This group was composed of 20 cases, and sympathectomy was of no value. Group II, the border line cases in which the operation may be justified in the hope of reducing the pain and checking the disease. This group was composed of 11 cases and there was only about 20 to 30 per cent general improvement in these patients. Group III was represented by patients suffering from the periarticular type accompanied by the neurocirculatory disease. In these patients the operation afforded relief from symptoms and checked the arthritic processes. Group III, namely, the periarticular cases with vasomotor spastic phenomena, was again divided into two subgroups: one, where the arthritic changes were the direct result of the vascular disturbance—for instance, the sclerodactylia in acral-scleroderma, Raynaud's disease, thrombo-angiitis obliterans, in which there was spasm of the collateral arteries—and a second group of patients who suffer from cold, clammy, pale and cyanotic extremities preceding or accompanying the arthritic changes. The patient which I wish to report is in this second subdivision. From the results obtained to date,

* Read before the Philadelphia Academy of Surgery, April 1, 1935.

it is apparent that lumbar ganglionectomy is indicated only in a small percentage of the great number of patients suffering from arthritis. It has not been used in osteo-arthritis, hypertrophic or degenerative arthritis.

The patient's general health should be maintained at the highest possible point at all times to obtain the best results. The postoperative restitution of use of the involved parts should be very slow and conservative. Heat and other physiotherapeutic measures should be used with moderation as indicated. Orthopedic measures should be instituted to correct or overcome deformities.

CASE REPORT.—The patient, a white female, aged 16, was admitted to the Presbyterian Hospital December 30, 1932. Chief complaint, arthritis of both ankles and feet. The history dates back to six years before admission when the patient had pain and swelling of both feet and ankles. This disability continued for three months with subsequent complete relief until three years ago. Then she had pain in the right arm, hand, leg and foot, with swelling of these extremities and their respective joints. Accompanying this was pain and lack of motion of the left side of her face, with inability to talk. She was treated at the Johns Hopkins Hospital for this condition for six months with complete relief. In both instances the diagnosis was arthritis. She was then perfectly well until ten months ago, when she again developed pain, swelling, and tenderness in the right ankle and foot, and also to a lesser degree the same symptoms in the left foot and ankle. Accompanying these symptoms she constantly complained of the extremities feeling cold, and when the feet hung down they become bluish-purple in color. This was more pronounced on the right than the left lower extremity. Her condition became so severe that she was confined to bed. Medical treatment over these ten months produced no improvement. She had been carefully studied for foci of infection in the past. Her tonsils were removed nine years ago and her appendix one year ago. A maternal aunt and paternal grandmother had arthritis. Otherwise the family history was negative.

Physical examination disclosed a fairly well nourished white girl, 16 years of age, who was confined to bed. There was moderate pallor and lack of facial expression. Temperature, 99.1°F., pulse, 100; respirations, 21; blood pressure, 90/50. The physical examination was essentially negative except for the lower extremities. There was a moderate degree of muscular atrophy from disuse of both legs and thighs, more marked on the right than the left. There was a visible enlargement of the right knee joint. The right ankle was swollen, red and tender. Motion was impossible because of pain. There was no pain in the knee joint. The physical findings were similar in the left ankle and foot but less pronounced. When the feet hung down they became distinctly bluish-purple in color; more marked on the right than the left. This disappeared when the feet were elevated, and they became a blanched white. To palpation the surface temperature was much lower in the involved parts. This was more marked on the right than the left. The lowered surface temperature extended above the knee on the right and to the middle of the calf on the left lower extremity. There were no physical findings in the heart but the electrocardiograms suggested mitral stenosis with a question of coronary stenosis with myocardial degeneration. Roentgenologic examination of the feet and legs showed moderately advanced atrophic arthritis, more marked on the right side. "There is no appreciable narrowing of joint space. The bony joint surfaces and outlines are very slightly irregular. The zone proximal to the joint space is well preserved. There is considerable atrophy over the lower end of the tibia and fibula and all bones of foot. In the lower tibia this atrophy appears ground glass in nature. There is some definite thickening of peri-articular tissue. Conclusions: Evidence of moderately advanced atrophic arthritis." Blood count: hemoglobin, 89 per

cent; red blood cells, 4,190,000; white blood cells, 4,600. Urine, negative. The clinical diagnosis was atrophic arthritis accompanied by or secondary to a vasomotor vascular disease of the extremities.

The patient remained in the hospital for a period of five months on the services of Doctors Pemberton and Klein. During this time all types of medical treatment had been instituted, including baking and massage, diet, injections of vasodilators and the intravenous use of typhoid vaccine. She constantly complained that her extremities felt cold. Two months after admission a roentgenogram showed more generalized atrophy when compared with the earlier films. Doctor Rowntree saw her at this time and suggested the use of diathermy to the lumbar sympathetics in addition to the intravenous administration of typhoid vaccine. Though no thermocouple was used, there was a palpable elevation in the surface temperature of the involved parts after the intravenous administration of the typhoid vaccine, whereas the mouth temperature rose only one degree; thus the vascular index was satisfactory for lumbar ganglionectomy.

After five months of medical treatment with no improvement, the patient was transferred to the surgical service of Doctor Speese, and on May 5, 1933, I performed a bilateral lumbar ganglionectomy and trunk resection. A peri-arterial sympathectomy was performed on the left common iliac artery. There was immediate improvement in the surface temperature and color of the affected parts while still on the operating table. The postoperative routine of gradual introduction of exercise to the involved parts was instituted. The patient left the hospital five weeks after the operation, able to walk carefully with crutches.

Subsequent Course.—She contipued with two crutches until two months after the operation, and one crutch for one month, and a cane for the succeeding three months. Since that time she has not used any artificial support.

When seen four months after operation she was using a cane, and walked with very little difficulty. Her general condition had improved greatly, the swelling of the parts had disappeared and there was only a slight degree of pain produced on motion of the involved joints. There was marked improvement in the lowered surface temperature and both feet were pink in color. She noted pains in the calves of her legs and dryness of the skin of the lower extremities. She was permitted to return to school.

After discarding the cane, only a limited amount of walking was permitted, but exercise was gradually increased. At first a twist of the ankle in walking would produce pain and slight swelling which would persist for 24 hours and then disappear.

On March 2, 1935, 22 months after the operation, her general appearance was that of a normal healthy girl. She had been able to attend school regularly for one and one-half years, and was able to walk an unlimited distance without any pain or disability, and has attempted dancing on a soft rug with no discomfort. She experienced slight pain in both ankles, more marked on the right, when she ran or jumped. The muscular atrophy had disappeared, the joints that were involved appeared normal in shape and size. The pains in the calves of the legs had disappeared six months ago. There was still some palpable difference in the surface temperature, though not nearly as pronounced, over the lower half of the right leg. There was no palpable lowering of the surface temperature on the left leg. A roentgenogram taken at this time showed no improvement in the atrophic disturbance in the bones, but there was no evidence that it had increased.

On April 1, 1935, the patient stated that she continues to notice a gradual increase in her ability to use the lower extremity, and to palpation there was no evidence of any lowered surface temperature in the right leg, which had been observed on March 2, 1935.

Discussion.—This case is presented because it illustrates the type of arthritis which may be benefited by lumbar ganglionectomy and trunk resec-

tion. It is probable that the greatest improvement has not as yet been obtained, as more improvement is noted as time goes on.

A cervicothoracic sympathectomy may also be performed when this condition exists in the upper extremities.

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THE THERAPEUTIC EFFECTS FOLLOWING INTERRUPTION OF THE SYMPATHETIC NERVES*

REPORT ON THE ALCOHOL BLOCK IN CERTAIN ARTHRITIC AND VASCULAR CASES

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THE autonomic nervous system was described 200 years ago (1732) by Winslow.[1] After extensive studies in morphology, the next great contribution to the anatomy of these nerves was made by Gaskell (1886–1889). Langley (1889–1921) developed a new approach to the understanding of these nerves by discovering the action of a drug, nicotin. The effect of drugs and animal experimentation furnished most of our knowledge until 1923, when Royle and Hunter,[2, 3] attempting to aid cases of spastic paraplegia, employed a third method of study—that of interrupting the sympathetics and observing the effects on the disease. In isolated instances, others had used this method before, but the great modern impetus was given by their work. Today we are able to state that the autonomic nervous system has a definite relation to certain diseases, and interruption of the proper nerves will greatly benefit these diseases.

As we have reviewed the literature, we have been profoundly impressed with the fact that the value of each article has been to a large extent proportional to the knowledge of the anatomy and physiology displayed by the author. This statement cannot be too forcibly emphasized, therefore we give brief outlines of anatomy and physiology with diagrams to which we have constantly referred, and which we hope will be useful to the reader.

ANATOMY OF THE AUTONOMIC NERVOUS SYSTEM.—The autonomic nervous system is composed of two parts: the sympathetic and the parasympathetic. Because the former is embryologically and anatomically connected with the thoracic and lumbar segments of the spinal cord, it is frequently spoken of as the thoracolumbar nervous system. For similar reasons, the latter is often called the craniosacral nervous system. Basically, the two systems are constructed according to a somewhat similar pattern. As illustrated in Fig. 1, the sympathetic reflex arc consists of a receptor or visceral sensory (afferent) neurone with its fiber, a connector or preganglionic neurone and its fiber, and an effector or postganglionic neurone and its fiber.

Extending from the base of the skull to the coccyx, along the anterolateral aspects of the vertebral column are two ganglionated sympathetic nerve trunks (Fig. 2). The ganglia are known as the vertebral ganglia and are in a general way segmentally arranged, except in the cervical region where there are only three sympathetic ganglia. From the first thoracic nerve to the

* Read before the New York Surgical Society, February 24, 1933.

second lumbar nerve the ganglia are connected to the spinal nerves by two rami, the gray and white rami communicantes. Elsewhere the ganglia are connected with the spinal nerves only by the gray rami. All of the ganglia are connected with each other by longitudinal fibers.

In addition to the vertebral ganglia, the sympathetic system has another

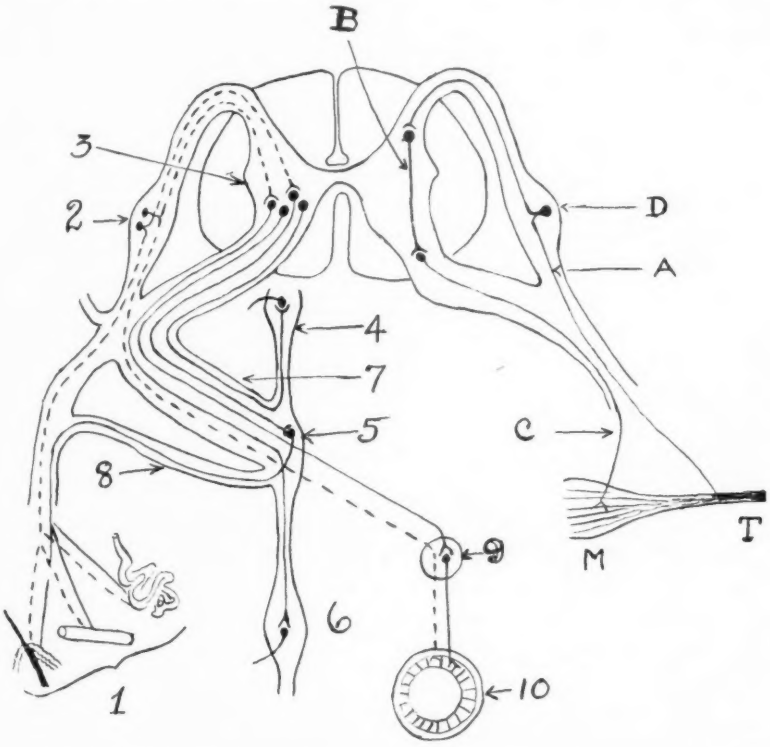

FIG. 1.—Reflex Arcs in the Cord. Left half of diagram, 1, 2, 3, *etc.*, involuntary system. Right half of diagram, A, B, C, *etc.*, voluntary system. (1) Group schematically shows hair, muscle, sweat gland and blood vessel equipped with visceral sensory or afferent fibers (dotted lines) and a postganglionic visceral motor fiber (solid line). (2) Dorsal spinal ganglion showing one visceral sensory neurone sending its fiber in the spinal nerve to the structures. Another visceral sensory neurone sends its fiber through the white ramus (7), the vertebral (5), and prevertebral ganglia (9), to a viscus (10). (3) Lateral horn or intermediolateral cell column showing four preganglionic cells whose fibers pass through the white ramus (7), and terminate at four different points: one preganglionic fiber forms a synapse with a postganglionic neurone in the sympathetic ganglion (5) attached directly to the spinal nerves; another forms a synapse in the ganglion above (4); a third forms a synapse in the ganglion below (6); a fourth passes through the vertebral ganglion (5) to form part of the splanchnic nerves, which terminate in a prevertebral ganglion (9). From (9) a postganglionic neurone extends to the viscus (10). A preganglionic fiber frequently extends two to four ganglia above or below its particular segment. (8) is a gray rami. (A)—Receptor or afferent fiber of the voluntary nerve system. (B)—Connector fiber. (C)—Excitor or efferent fiber. (D)—Dorsal root ganglion. (M)—Muscle. (T)—Tendon.

set of ganglia located about the aorta and its larger branches (Fig. 2). These are known as the prevertebral sympathetic ganglia. The celiac, superior mesenteric, aorticorenal and inferior mesenteric ganglia belong to this group. Fig. 1 illustrates the connections of the preganglionic fibers with these ganglia. Fig. 3 illustrates schematically the origin and distribution of the autonomic nervous system.

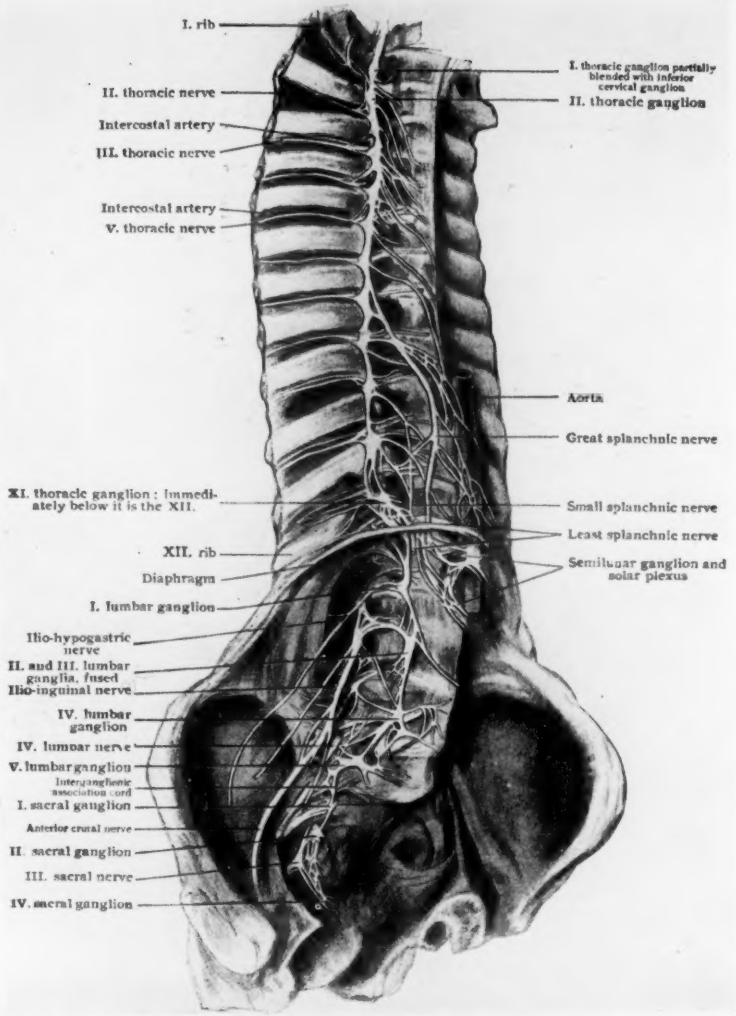

FIG. 2.—Dissection showing thoracic, lumbar and sacral portions of right gangliated cord and their branches (Piersol).

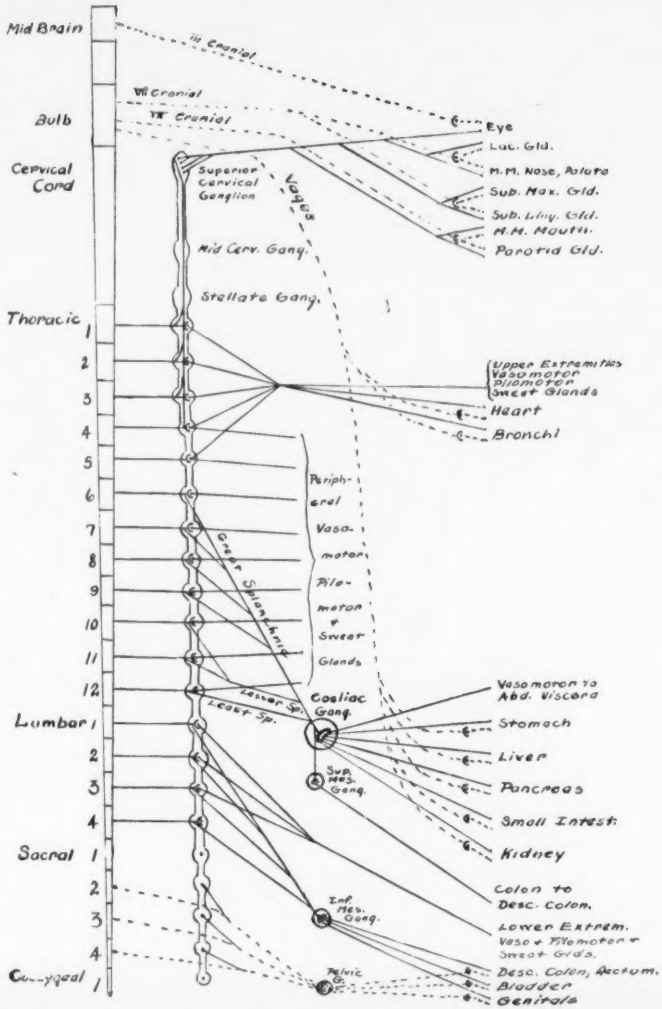

FIG. 3.—Diagram of the autonomic nervous system. The sympathetic division shown by solid blocked lines; the parasympathetic by dotted lines.

PHYSIOLOGY OF THE AUTONOMIC NERVOUS SYSTEM

	Sympathetics	Parasympathetics
Eye	Dilates pupil and widens palpebral fissure	Constricts pupil and narrows palpebral fissure
Salivary Gland	Controls ferment formation and constricts arterioles	Causes secretion of salts and water and dilatation of arterioles
Head and Mucous Membrane	Vasomotors	
Heart	Accelerates	Slows
Bronchi	Dilate	Constrict
Upper Extremity	Constricts blood vessels, pilomotor, causes "goose flesh" and sweating	
Stomach	Inhibits peristalsis and secretory activity	Stimulates
Liver	Stimulates conversion of glycogen into glucose	Opposes
Pancreas		Stimulates flow of pancreatic juice
Intestines up to Descending Colon	Inhibit peristalsis and secretory activity	Stimulate
Kidneys	Modify blood supply	
Descending Colon and Rectum	Relax	Contract
Sphincters	Contract	Relax
Lower extremities	Vasomotor, pilomotor, cause "goose flesh" and sweating	
Pain	Fibers are carried in autonomic nerves from viscera	

INTERRUPTION OF THE SYMPATHETIC NERVES.—One of the best methods of studying the autonomic nervous system is to interrupt various parts of it and then consider the physiologic and clinical effects which follow.

A. *Interruption of All the Sympathetic Nerves.*—Cannon[4] completely extirpated all the sympathetic trunks in cats. The cats bred and fed their young in a normal way. They ate well and digested their food. Their metabolism was reduced about 10 per cent. They could not elevate their hair coat. They got a Horner's syndrome, but it was transient. They were very sensitive to cold. Kittens who had all sympathetics removed on one side developed symmetrically. In a warm quiet laboratory, where the sympathetics are not essential, they live quite comfortably. Cannon believes, however, that only in a protected environment could such animals survive.

B. *Interruption of the Cervical Sympathetic Nerves.*—Interruption of the cervical sympathetic nerves produces a syndrome first described in 1869 by

Horner[6] as consisting of enophthalmos, miosis, pseudoptosis and cessation of sweating on the affected side of the face. It was 20 years later before the cervical sympathetic nerve was divided or resected in the hope that the resulting Horner's syndrome would benefit cases of exophthalmic goiter and glaucoma.[5] According to Parsons,[7] the benefit in two cases of exophthalmic goiter seemed to be due to a paralysis of Müller's muscle. There was no resultant decrease in the exophthalmos. Parsons stated further that he would hesitate to use the operation on both sides because of possible interference with night vision. Adson, however,[8] reports that the condition, when bilateral, is rarely complained of unless unequal. He also states that there is no serious interference with vision in the dark. White[9] found only a slight Horner's syndrome appearing when the upper dorsal ganglia were blocked, but if the inferior cervical ganglion is included a permanent Horner's follows. We have found this to be true in the cases we have done.

Cervical sympathectomy has also been done for bronchial asthma. Conflicting reports are given out as to the results obtained. When we realize that the constricting nerve fibers to the bronchi come from the vagus nerve and the dilating fibers come from the sympathetic nerves, then the removal of the cervical sympathetic ganglia for the treatment of bronchial asthma seems to have no anatomic or physiologic basis.

Formerly it was thought the lowest fibers to the heart ran from the stellate ganglion with the inferior cardiac nerve. Cervical sympathectomies were found to be not entirely effectual in stopping the pain of angina pectoris. In 1927–1930, various workers [10, 11, 12] showed that, in addition to the middle and lower cardiac nerves, afferent impulses from the heart also run across the posterior mediastinum to the upper dorsal sympathetic ganglia. Blocking or resecting these latter ganglia has been very successful in a large number of cases.

C. *Interruption of the Sympathetic Nerves to the Extremities.*—Probably more attempts have been made to benefit disease by interrupting the sympathetic nerves to the extremities than by their interruption to any other part of the body. In 1923, during Royle's[3] extensive work on removing the sympathetic nerves for the treatment of spastic paralysis, he discovered the side operated upon was warmer and showed capillary dilatation. The profession was very quick to seize upon this idea and apply it to increase the circulation in many types of vascular disturbances.

It is now pretty well established that all of the vaso-constrictors to the upper extremity come off as gray rami from the inferior cervical and first and second thoracic sympathetic ganglia. If these three ganglia are resected or blocked, there is complete paralysis of all vasomotor nerves to the extremity. This has been substantially proved by Kuntz,[13] White,[14] and Adson.[15]

Complete vasomotor paralysis to the lower extremity is obtained by resection or blocking of the second, third and fourth lumbar sympathetic ganglia and trunk, because all postganglionic neurones and their axones (gray rami)

to all the spinal nerves below the first lumbar are supplied by the preganglionic fibers coursing through these three sympathetic ganglia.

In experimental animals after sympathectomy to the extremity, the circulation returns to approximately normal in ten days or two weeks.[16] In a perfectly normal human being, the same thing might happen, though more slowly. There is abundant evidence to prove that when there is a vasomotor neurosis or exaggerated vasomotor tonus, as in cases of Raynaud's disease, Buerger's disease, and scleroderma, the release of the constricted blood vessels will last for a period of many months, if not permanently.[8, 9] After a fairly thorough review of the literature and an appraisal of our work, we may say that great benefit has been reported in cases of Raynaud's disease, thromboangiitis obliterans, scleroderma and amputation stump pains.

From a surgical point of view, a most interesting observation has been made. Mulvihill and Harvey[17] found that ligation of a dog's iliac artery close to the aorta was always followed by a 10° to 30° Fahrenheit decrease of temperature in the corresponding foot; but if lumbar sympathectomy was done at the same time as the ligation of the iliac artery, then no fall of temperature occurred.

D. Peri-arterial Sympathectomy.—In recent years, there have been few operations more widely discussed than that of peri-arterial sympathectomy, which consists in removing the adventitia with its nerve plexuses from a portion of a large blood vessel. Although others carried on experiments many years previously, Leriche[18] in 1916 performed this operation for a number of clinical conditions and reported successful results in most of them. Until recently, there were more favorable than unfavorable reports on the results of clinical cases so treated. On an anatomic and physiologic basis, such a procedure must be justified by assuming that arteries to the extremities, like those of the thoracic and abdominal cavities, carry their sympathetic nerve plexuses from the aorta throughout their distribution. More recent work offers unquestionable proof that such is not the case (Fig. 4). Instead, the arteries of the extremities derive

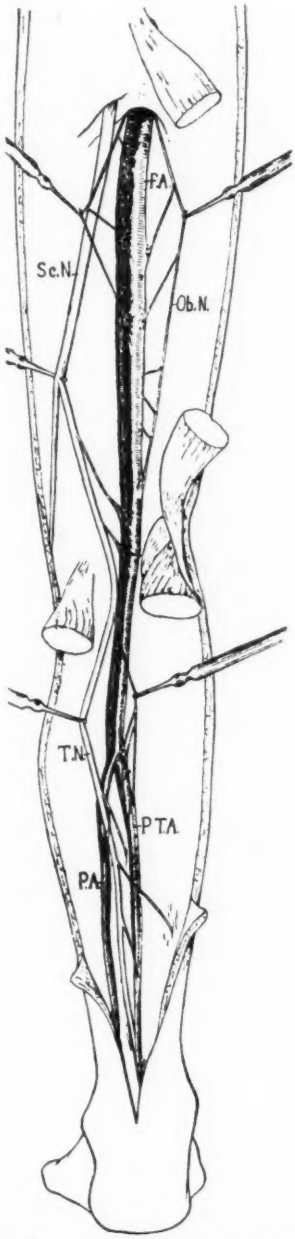

FIG. 4.—Illustrating the fact that arteries to the extremities derive their nerve supply mainly from adjacent peripheral spinal nerves. These arteries do not carry their sympathetic nerve plexuses with them from the aorta, as do the arteries to the thoracic and abdominal cavities (Kuntz).

their nerve supply mainly from adjacent peripheral spinal nerves.[19, 20] Branches of these nerves, including fibers of the sympathetic (gray rami) and spinal ganglion origin join the peripheral arteries at intervals corresponding with the somatic segments. Formerly, Adson[21] did a peri-arterial sympathectomy on the common iliacs in conjunction with lumbar ganglionectomy. To quote: "However, we soon learned that if on one side we did unilateral peri-arterial neurectomy in addition to lumbar sympathetic ganglionectomy, and on the other side we did lumbar sympathetic ganglionectomy alone, the changes in the surface temperature on the two sides were the same." Rogers and Heminway[22] performed a peri-arterial sympathectomy on the carotid artery of a rabbit. They also divided the cervical sympathetic chain of a rabbit. The former procedure caused congestion of the rabbit's ear for about two days, but the latter procedure lasted longer. Horton and Craig[23] did a lumbar ganglionectomy on one side of a dog. They then did a peri-arterial sympathectomy on one lower extremity of another dog. They then injected mercury into the abdominal aortas of these two dogs. Dilatation was much greater in the extremity of the dog with the ganglionectomy. In two cases, White[24] injected the sciatic nerve for pain. At the same time, he noted an increase in the peripheral surface temperature comparable to that produced by sympathetic ganglionectomy or spinal anesthesia. We are forced to conclude, then, that peri-arterial sympathectomy brings about only slight sympathetic denervation of a peripheral artery, and there is no rational anatomic or physiologic basis for this operation as a clinical procedure.[25]

E. *Interruption of the Sympathetic Nerves for Spastic Muscles.*—The sympathetic nerves to the extremities have been removed by Royle[26] and others in cases of spastic paralysis. In 1931, Royle had done more than 600 such operations with 0.5 per cent mortality. The assumption was that there is a relation of the muscle tonus to the sympathetic nervous system. Several surgeons[27, 28, 29, 30] have followed cases operated upon by Royle. They believe that sympathetic nerves do not exist in skeletal muscles, and any benefit from sympathectomy in spastic conditions is due to increased blood supply and increased metabolism to the spastic muscles.

F. *Interruption of the Sympathetic Nerves for Amputation Stump Pain.*—Resecting or blocking the sympathetic nerves is of interest to surgeons if it will stop pain in amputation stumps. We have employed this procedure in one case—a traumatic stump of the middle of the left forearm. No improvement was noted. However, White and others[11] report excellent results in a few cases. It is well known to all surgeons that pain fibers, whether sympathetic or not, are carried in blood vessel walls,[10] also that amputation stumps are often cold and their blood supply deficient. Interrupting the sympathetic nerves may benefit in those two ways.

G. *Interruption of the Sympathetic Nerves to the Colon.*—Unilateral or bilateral resection of the four lumbar sympathetic ganglia for cases of megacolon (Hirschsprung's disease) was first done by Wade and Royle,[31]

in 1927. Learmouth and Markowitz[32] demonstrated that "electric stimulation of the corresponding nerves of the bowel leads to dilatation of the colon and to contraction of the internal sphincter of the rectum, and contraction of the internal sphincter has been demonstrated by Rankin and Learmouth in the human being, when nerves are stimulated." Morton and Scott[33] have developed a diagnostic test to detect the proper case of megacolon which will respond well to sympathectomy. They give a barium enema and ask the patient to attempt to empty the bowel—they then paralyze the sympathetic nerves with a spinal anesthetic and ask the patient to again try to empty the bowel. If most of the bowel is thus emptied it is regarded as a favorable case for permanent sympathetic interruption.

Methods of Interrupting the Autonomic Nervous System.—A. *By Extirpation.*—It goes without saying that the surest way of stopping all function in a part of the body is to remove that part from the body. As we have mentioned above, isolated cases of extirpation were done until 1924 when Royle[3] and Hunter[34] reported results of their extensive work on animals, and the clinical results on a large series of spastic paraplegics. Following Royle's report, Adson,[21] Diez,[35] Ito and Asami,[36] Loyal Davis and Kanavel,[37] White,[9] and many others have done sympathetic ganglionectomy and ramisectomy for many clinical diseases. The permanency of such a procedure is not definitely known. White[38] quotes Brücke's work which points to the regeneration of fibers at the rate of 1 Mm. per day. He also quotes the work on cats and monkeys by Tower and Richter who proved by measuring the electrical resistance of the skin that it returned to normal in about 28 days after certain sympathetic fibers were cut. Of course excision of a nerve cell must destroy all function of that cell and its fibers. However, the function of this cell might conceivably be taken over by another cell. Judging by vasomotor paralysis in the extremities of human beings following sympathectomy, there is strong evidence to prove that it is permanent if all of the postganglionic fibers (gray rami) to the blood vessels of the extremity are resected.[9, 39, 44] However, it is the opinion of W. D. Andrus that regeneration or recovery of local tone returns in a few weeks to a few months. For the technic of removal by operation the reader is referred to articles by Adson,[15] Flothow and Swift,[40] and Stewart.[41]

B. *By Spinal Anesthesia.*—A second method of interrupting sympathetic nerve action is by spinal anesthesia. Of course, this is practical only in the abdomen and lower extremities. White[24] advises that the anesthesia should reach to the sixth dorsal segment; therefore, skin anesthesia must rise to the level of the xiphoid cartilage. One advantage is that after the effects are noted and found favorable, a lumbar sympathectomy can be done under the same anesthetic. The idea of giving spinal anesthesia for ileus was to paralyze the splanchnic sympathetic nerves, give the vagus control, and thereby increase peristalsis and relax sphincters. Physiologically, this is sound if there is no contra-indication for, or mishap with, this type of anesthesia. Woodbridge[42] advises that to obtain full effects the following drugs should

not be used: ephedrine, atropine, chloroform, ether and epinephrine. White has always obtained complete vasodilatation to the lower extremities with spinal anesthesia and ephedrine given at the same time.

C. *By General Anesthesia.*—Scott and Morton[43] have found that vasomotor tone is lost under a general anesthesia of ether, nitrous oxide or avertin. This is temporary and not practical in every case, but it is a quick method of determining just what effects paralyzing the sympathetic nerves will have on the circulation to a part. Sympathectomy or blocking with alcohol may then follow.

D. *By Injection of Mixed Nerves.*—Injecting the mixed peripheral nerves with certain drugs produces paralysis of the sympathetic fibers contained therein. For instance, if the sciatic nerve is blocked as it emerges from the greater sciatic foramen, complete vasodilatation of the arteries of the lower leg and foot is obtained, and the increase in surface temperature is comparable to that obtained by lumbar ganglionectomy.[20, 24, 37] Blocking other nerves of the extremities gives similar results over areas corresponding roughly to the peripheral distribution of the nerve injected.

E. *By Crushing or Dividing Peripheral Nerves.*—Smithwick and White[45] obtained the effects of ganglionectomy, lasting three to six months, by crushing with a hemostat certain branches of peripheral sensory and mixed nerves. Laskey and Silbert[46] accomplished the same effect by dividing those nerves and then immediately suturing. We have obtained similar results in three cases done by both methods.

F. *By Blocking.*—In 1925, Mandl[47] first advocated the method of blocking the sympathetic nerve ganglia and fibers by direct injection of procain in or about these structures. Soon afterwards, the method was taken up in this country by Swetlow,[48] White,[12] Woodbridge,[42] Flothow,[49] and others. As a diagnostic test, White in 1929 began blocking the sympathetic nerves to the arms and legs with procain hydrochloride. He found that for a period of two to four hours after blocking with procain, all the effects of a ganglionectomy were secured; namely, paralysis of the vasomotors, suppression of sweating, and, he believed, relief of pain over the referred sympathetic nerves. Very soon after White's work, Flothow blocked the sympathetic nerves with alcohol in 64 various cases and reported very satisfactory results.

Blocking the Sympathetic Nerves.—A. *Advantages.*—(1) Thus far, no fatality or serious complications from blocking by procain or alcohol have been noted in the literature. (2) Blocking is a procedure which may be carried out in the clinic and does not necessarily require hospitalization of the patient. (3) Blocking may first be done with novocain and the effects noted while the needle is left in place; and after the desired effects are obtained, they may be made more lasting and possibly permanent by then injecting alcohol through the same needle. We now believe that some form of diagnostic test should always be made prior to the operative procedure so as to determine the probable efficacy of resection. (4) Blocking has the advantage over other methods of interrupting because it is selective, leaving the other

nerves of the extremity intact. (5) Blocking is superior to protein shock in that the maximum effect from paralyzing the vasoconstrictors is produced in the region desired without a generalized reaction with fever and malaise which requires hospitalization. (6) Occasionally, blocking offers a complete relief of symptoms for a prolonged time varying from a few days to permanence.[12]

B. *Disadvantages.*—Of course, success is absolutely proportional to the accuracy of the technic of injection. One is not justified in attempting to block these nerves and ganglia until he has perfected the technic on cadavers, and until he is familiar with the complicated anatomy and physiology. (1) The solution may not be injected in the right position anatomically. (2) The effects may not be as lasting as in ganglionectomy. (3) Extension of the injected fluid may take place and more nerves than necessary are blocked.

FIG. 5.—Illustrates position of patient for dorsal block.

(4) Following alcohol injection, an operation, if indicated, might be technically difficult. (5) Theoretically serious injury may be done to surrounding structures but such has not been reported. Frequently the injected alcohol irritates the intercostal nerve trunks, resulting in intercostal neuritis which may last from a few minutes to four or five weeks.[50] This has happened in some of our cases but mild anodynes usually controlled the condition.

C. *Technic of Blocking.*—The technic of blocking described and performed by most workers is that of Labat.[51] The first paper to attract our attention was that of Flothow, who described Lundy's method.[49] We have followed this method in practically every case. It has the advantage of being the same in all dorsal and lumbar injections. Briefly, the method is as follows: Place the patient prone on a Gatch bed with his head toward the foot of bed. Any part of the spine may now be flexed by elevating the part of the bed ordinarily used for raising the patient's knees (Figs. 5 and 6). This may be accomplished also by placing pillows under the chest or abdomen of

a patient lying in bed or on a table. Labat's needles and syringes are preferable. The intervals between transverse processes lie approximately opposite the spinous processes in the dorsal region and opposite the interspinous

FIG. 6.—Position of patient for lumbar block.

spaces in the lumbar region. The needle placed about 2½ to 3 cm. lateral to the spinous processes is thrust directly forward until the transverse process or the body of the vertebra is struck. Procain is continuously injected ahead

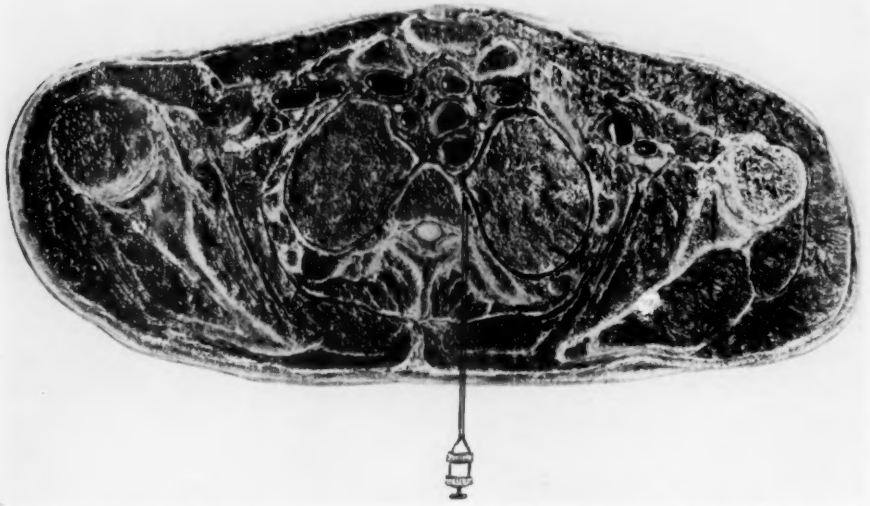

FIG. 7.—Cross-section through the upper dorsal region showing the needle in place for sympathetic nerve block. We use Lundy's technic of direct insertion of the needle.

of the advancing needle (Figs. 7 and 8). By slightly shifting the needle it is, in a way, slid around the side of the vertebra, reaching its anterolateral aspect at which point the sympathetic ganglion and nerve fibers lie. In the dorsal region the posterolateral aspect of the vertebral body is usually reached

between 4 and 5 cm. from the skin. The sympathetic ganglion is reached between 5 and 6 cm. from the skin. In the lumbar region the body is usually about 6 cm. and the sympathetic ganglion about 7 or 8 cm. from the skin. Most workers have used rather large quantities of procain and alcohol so as to be sure of surrounding the sympathetic ganglia. We have tried to be a little more selective and have used rather small quantities of solution, varying from 2 to 5 cc. We have always used 2 per cent procain and absolute alcohol. In one patient we blocked the sympathetic nerves simultaneously to two extremities. At a later date the sympathetic nerves of the other two extremities were injected. There have been no serious complaints from patients subjected to the procedure.

FIG. 8.—The needle in place for lumbar sympathetic nerve block.

All of our injections have been done when the constant room temperature of our laboratory was about 65°F. The patient was usually in the laboratory for 15 minutes before initial readings were taken. We have taken surface temperature readings of our nerve blocks as follows (Fig. 9): (*a*) Readings at various levels over anterior and posterior surfaces of both extremities. (*b*) Then block the sympathetics of one extremity with procain, leave needles in place, wait 15 minutes, then take readings on both extremities. (*c*) Inject alcohol through needles which are still in place, waiting 15 minutes to repeat readings on both extremities. (*d*) Take readings thereafter at weekly or monthly intervals.

D. *Duration of Block.*—The duration of the alcohol block is variously

estimated. To date, relatively few cases have been treated, and in so new a field certainty is still questionable. To my knowledge, two anginal cases done by White are the longest on record.[12] He reported complete block existing after intervals of one and five years. I know of only one autopsy after an injection of alcohol. White had a case of aortic aneurysm, which was completely relieved of pain, but death occurred three months later as

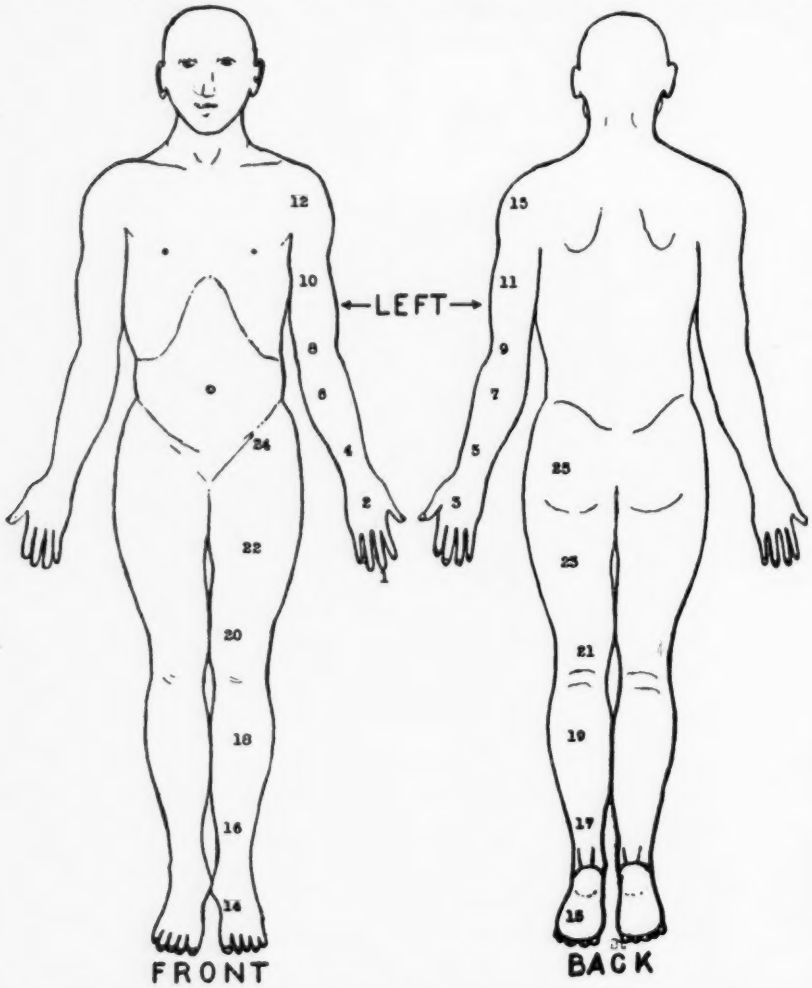

FIG. 9.—Shows points at which surface temperature readings were taken.

the result of an anterior perforation of the aneurysm. Autopsy showed definite scars about 1 cm. in diameter in the region of the first and second dorsal foramina. The small fibers of the rami were imbedded in the scar and it was impossible to follow them through it. The scar did not involve the spinal nerve trunk, although it partially surrounded it.

INTERRUPTING THE SYMPATHETIC NERVES IN ARTHRITIS.—The only sympathetic nerves going to the upper extremity are the gray rami from the

inferior cervical and first and second thoracic ganglia. All sympathetic nerves to the lower extremities are supplied through preganglionic fibers to and through the first, second, and third lumbar ganglia, hence these two sets of ganglia must be blocked if all four extremities are to be treated.

A. *Reports from Other Clinics.*—Rountree,[52] in 1926, first suggested that interrupting these nerves be tried in cases of polyarthritis. He recommended that the procedure be limited to young persons who have shown no improvement with medical treatment and who complain of cold, wet, pale, clammy skin, and painful, swollen, tender joints with atrophy and contraction of the muscles, and especially those cases where the arthritis was worse in the hands, wrists, feet, and ankles. Flothow[53, 49] reports great benefit in a few cases of arthritis. He states that a Japanese has performed sympathectomies in 120 cases with uniformly excellent results. White[14] did a ganglionectomy on two cases with no improvement in joint stiffness or pain, but stated that both patients enjoyed warm dry hands instead of cold clammy ones. Leriche[54] has used the procedure in traumatic arthritis, with unusually good reports of improvement from chronic vasomotor spasm, edema, decalcification and pain in the injured joint. Enthusiastic reports are greatly in the majority.

B. *Alcohol Block in Patients with Rheumatoid Arthritis.*—Based on reports from other clinics, as to the type of case which responded best to sympathetic interruption, we chose patients whose arthritic manifestations were confined largely to the hands, feet, or both, and whose extremities showed vasomotor disturbances as indicated by cold clammy hands and feet. Care was taken to select patients whose joints showed primarily peri-articular swelling and increase of joint fluid rather than those who showed hypertrophic joint changes.

Altogether, 11 cases with rheumatoid arthritis were studied. Their average age was 41.9 years. The duration of symptoms averaged 18 months for ten cases and seven years for one case. Every case was selected from the arthritis clinics at Bellevue Hospital and Cornell Clinic and carefully worked up. All had been under observation for several months and were believed to be free from foci of infection. Several of them had been treated with streptococcus vaccines, physical therapy, diets, *etc.*, without beneficial results. The clinical impression was confirmed in all cases by positive streptococcus agglutination with arthritis hemolytic streptococci.[55]

The technic of blocking was similar to that already described. In the dorsal region, the injection was usually made about the area of the second thoracic ganglion. In several instances, the first and third were also injected, but as a rule this appeared to be unnecessary, as no additional temperature change was obtained, the solution spreading from the second sufficiently to block the first and third. The surface rise in temperature of the upper extremities was good (Table I), even though all the sympathetic nerves could not have been blocked unless the inferior cervical ganglion area were included.

TABLE I

RÉSUMÉ OF RESULTS WITH ALCOHOL BLOCK IN PATIENTS WITH RHEUMATOID ARTHRITIS

Case	Site of Injection *	Alcohol Injected †	Increase in Temperature ‡ Following Injection: Toe or Finger	Knee or Elbow	Inguinal or Shoulder	Remarks
1	Right lumbar 1 and 2...	10 cc.	12.3°	2.4°	0.3°	
2	Left dorsal 1, 2 and 3...	5 cc.	0.0°	0.0°	0.0°	Missed
	Right dorsal 1, 2 and 3.	5 cc.	2.5°	0.0°	0.0°	Missed
	Right lumbar 1, 2 and 3.	5 cc.	12.0°	3.2°	1.9°	
	Left lumbar 1, 2 and 3..	5 cc.	7.1°	4.9°	0.8°	
3	Left lumbar 1, 2 and 3..	5 cc.	0.0°	0.0°	0.0°	Missed
	Right dorsal 1, 2 and 3..	5 cc.	4.5°	1.0°	1.0°	
	Right lumbar 1, 2 and 3.	2 cc.	4.4°	5.1°	2.0°	
	Left dorsal 1, 2 and 3...	2 cc.	12.4°	7.9°	2.1°	
4	Left lumbar 1, 2 and 3..	4 cc.	15.5°	0.3°	0.0°	
	Left dorsal 1 and 2.....	2 cc.	5.7°	2.8°	3.7°	
	Right lumbar 1, 2 and 3.	4 cc.	8.7°	4.4°	2.6°	
	Right dorsal 1 and 2....	2 cc.	10.4°	4.8°	2.0°	
5	Left dorsal 2.....	2 cc.	20.5°	6.2°	2.0°	
	Right lumbar 1, 2 and 3.	5 cc.	4.6°	4.5°	1.2°	
6	Right lumbar 1, 2 and 3.	4 cc.	22.0°	4.6°	2.1°	
	Left lumbar 1, 2 and 3..	5 cc.	17.5°	2.7°	0.7°	
	Left dorsal 2.....	5 cc.	14.6°	5.5°	2.7°	
	Right dorsal 2.....	4 cc.	14.9°	7.9°	3.5°	
7	Left lumbar 1, 2 and 3..	4 cc.	7.6°	1.0°	0.9°	
	Right lumbar 1, 2 and 3.	4 cc.	7.0°	0.8°	1.2°	
8	Right dorsal 2, 3 and 4..	21 cc.	12.8°	6.1°	0.5°	
	Left dorsal 2, 3 and 4...	2 cc.	4.5°	2.9°	0.6°	
9	Left dorsal 1 and 2.....	4 cc.	12.1°	2.6°	1.2°	
	Left lumbar 1 and 2....	4 cc.	11.2°	3.1°	1.0°	
	Right dorsal.....	4 cc.	9.0°	6.1°	4.4°	
	Right lumbar 1 and 2...	4 cc.	0.0°	0.0°	0.0°	Missed
10	Left dorsal 2.....	5 cc.	10.9°	5.5°	1.8°	
	Right dorsal 2.....	5 cc.	10.6°	6.4°	3.7°	
11	Left dorsal 1 and 2.....	5 cc.	7.5°	6.8°	4.2°	
	Right lumbar 1, 2, 3 and 4	5 cc.	7.3°	3.6°	1.4°	
	Right dorsal 1 and 2....	4 cc.	13.3°	12.3°	4.7°	
	Left lumbar 1 and 2....	4 cc.	20.0°	3.3°	0.0°	

* The figures refer to the ganglion areas injected.

† Under "alcohol injected" are given the amounts of absolute alcohol injected into or around each ganglion.

‡ All temperature recordings are in Fahrenheit.

To do so would have produced a Horner's syndrome and we did not think this justifiable in cases of arthritis.

In the lumbar region, we usually blocked the first, second and third ganglion areas. All sympathetics to the lower extremities should be blocked even by injecting the second and third. In one case we resected the lumbar second, third, and fourth sympathetic ganglia and rami on the left side but, because of numerous old abdominal adhesions, we did not resect them on the right side. Thirteen weeks later, we blocked the first and second lumbar with procain and alcohol. Five days later the blocked extremity (right) was about 1°F. warmer than the side operated upon (left). This case would lead us to believe that alcohol block is as satisfactory as ganglionectomy.

Two to 5 cc. of 2 per cent solution of procain were first injected and, with the needles still in position, the patient's condition was observed for at least 20 minutes. If temperature changes took place in the extremities and no unfavorable symptoms or signs developed, such as a Horner's syndrome, 2 to 5 cc. of absolute alcohol were injected in each area and the needles withdrawn. A summary of temperature changes following the alcohol injections is given in Table I. The temperature readings were made 15 to 30 minutes after the alcohol had been inserted, at which time the patients appeared to have obtained their maximum temperature rise in the extremities.

Considerable variation occurred as regards temperature elevation among the different patients and different extremities of the same patient. In three instances, the sympathetic fibers appeared to have been missed entirely. The greatest change is observed at the tips of the fingers and toes, considerably less change at the elbow and knee, and only a very slight variation at the shoulder and inguinal region (Table II).

TABLE II

AVERAGE RISE IN TEMPERATURE IN DIFFERENT CASES OF ARTHRITIS

	Great Toe	Knee	Inguinal Region	No. of Extremities
Lumbar Injections	11.6° F.	3.3° F.	0.97° F.	12
	Finger Tips	Elbow	Shoulder	
Dorsal Injections	10.9° F.	5.6° F.	2.2° F.	15

The patients subjected to alcohol block were all observed for several months to a year, and surface temperature readings repeated at varying intervals. The increased temperature lasted an average of six months. The duration of the temperature changes varied considerably in individuals and extremities of the same individual, depending probably on the extent of the alcohol infiltration in and about the nerve fibers and cells, upon the reaction of the individual and perhaps upon the dilution of the absolute alcohol by the procain solution. To inject the alcohol without procain would produce the maximum block, but it would subject the patient to an unnecessary

amount of pain and at the same time eliminate the opportunity to observe the effects of a preliminary procain block. We have not as yet an accurate method of measuring the permanent effects following interruption of the sympathetic nerves. If we knew the total blood flow through a part, or the total heat given off, we would have an accurate method of measuring the temporary and permanent effects following interruption of the sympathetic nerves. We cannot obtain this information with the instruments now used.

Of considerable importance is the effect of this procedure on the arthritic process. On the whole, the results in this respect were very disappointing. Although two patients showed definite diminution of the arthritic process, the others showed little or no improvement in the joint condition. While the number of cases in this series is too small to warrant definite conclusions, it seems altogether unlikely that the course of the disease is favorably modified by interrupting the sympathetic nerves.

On the other hand, symptoms related more closely to faulty circulation were definitely improved. The change of cold clammy hands and feet to ones warm and dry was appreciated by the patients. The feeling of numbness, so frequent in patients of this type, was most often completely relieved.

Considerable attention was directed toward observing and recording unfavorable signs and symptoms. Almost all patients complained of some pain at the site of injection, but this usually subsided in a few hours to two days, and was never severe enough to be a serious factor. Difficulty in breathing was also complained of in a few instances, but this also disappeared after a few hours or a few days. Following injection of the lumbar nerves three patients developed hyperesthesia and myalgia in the thighs. With two of these patients the symptoms were mild and passed away gradually in one to two weeks. With the other one the distress was quite severe, and remained a source of constant annoyance for a period of approximately six months. He was able, however, to proceed with his usual occupation. Horner's syndrome was observed in several of the patients but it generally subsided in a few hours or a few days. In one instance, the signs of Horner's syndrome were marked, and persisted one year after the injection, although the patient said it caused him no pain or inconvenience. During the year the signs gradually became less marked, and at last examination were only moderately noticeable.

Associated with temperature changes in the extremities is a marked improvement in the circulation. At times the fingers and toes take on a reddish blush which persists for several days. The extremities become warm and dry instead of being cold and clammy.

Alcohol Block in One Case of Raynaud's Disease with Arthritis.—CASE REPORT.—J. J., male, aged 22, barber, admitted to Bellevue Hospital February 9, 1932, with a history of painful, swollen, clammy hands and feet of nine months' duration. In addition, there was pain in the elbows, shoulders, and knees. Physical examination was unimportant except for that found in the extremities. The hands were cold, clammy, and

bluish in color, these signs increasing in extent during examination and decreasing again when placed under the bedclothes. The proximal interphalangeal joints of the hands, as well as of the feet and ankles, were slightly swollen. This patient also had marked vasomotor disturbances of the face, neck, and tongue, as was indicated by the ready flushing of these structures from even a sight amount of emotional excitement. A diagnosis of Raynaud's disease complicated by some rheumatoid arthritis was made.

Five cc. of a 2 per cent procain solution injected into the first, second, and third left thoracic sympathetic ganglion areas resulted in a marked rise in surface temperature of the left arm (Table III). As there were no unfavorable effects, 4 cc. of absolute alcohol were also injected into each area. After one week, the sympathetic nerves to the right upper extremity were similarly blocked.

TABLE III

RISE IN TEMPERATURE IN ONE CASE OF RAYNAUD'S DISEASE

	Finger Tips	Elbow	Shoulder
Left	22.8° F.	6.5° F.	1.8° F.
Right	10.2° F.	5.2° F.	2.4° F.

Following the alcohol injection the patient developed a mild intercostal neuritis which cleared up in two weeks. The symptoms and signs of Raynaud's disease completely disappeared and remained so for nine months, the period of last observation. The arthritis, on the other hand, showed little or no improvement. During the nine-month period following the injection, the patient was able to carry on his usual occupation, which he was not able to do prior to the treatment.

Alcohol Block in One Case of Thrombo-Angiitis Obliterans.—CASE REPORT.—W. B., aged 45, an electrician, was admitted to Bellevue Hospital April 4, 1932. He gave a history of pain in the feet and calves of the legs of eight months' duration, with coldness and bluish discoloration of the toes of the left foot. There was also a prickly sensation in the toes and fingers. One year previously he had had similar symptoms which necessitated amputation of the second toe of the left foot for gangrene. He had also had a perforated gastric ulcer ten years previously. Physical examination revealed marked abnormalities in the extremities. The tip of the third toe of the left foot was almost black in color, while that of the fourth toe on the same side was dark purple. The left dorsalis pedis pulsations were feeble and the right entirely obliterated. The blood pressure was 160/100 and the urine showed three plus albumen.

On April 14, 1932, the left second, third, and fourth lumbar sympathetic ganglion areas were blocked with 2 per cent procain and then with absolute alcohol. Within 15 minutes after the procain injection the toes of the left foot were 10.7° F., the knee 2.6° F., and the inguinal region 1.1° F. warmer.

Rapid improvement in symptoms and signs occurred, and the patient was discharged from the hospital five days after treatment. On January 30, 1933, more than nine months after the injection, the patient stated that he had been symptom free the entire time, except for some pain in the legs which followed brisk walks of over one-half mile.

This case is one of eight so treated. We are enthusiastic about alcohol block in such cases. We greatly prefer this form of treatment to protein shock or injecting or cutting the peripheral sensory nerves. With the latter procedure, most careful technic must be used or else serious damage will be done to blood vessels that are barely able to carry on, and to tissues with scarcely any resistance to trauma and infection.

CONCLUSIONS

(1) Diseases definitely benefited by interrupting the sympathetic nerves are: Raynaud's, thrombo-angiitis obliterans, scleroderma, cardiac and aortic pain, megacolon.

(2) Arthritic cases with marked vasomotor spasm and cold clammy extremities are greatly helped symptomatically, but there seems to be little or no benefit on the progress of the disease itself.

(3) The diagnostic procain block should always be done before an attempt is made to permanently interrupt the sympathetic nerves.

(4) Blocking the sympathetic nerves with alcohol seems to be an excellent substitute for operative procedures.

(5) The technic of blocking should be carried out only after acquiring a thorough knowledge of the anatomy and physiology of the autonomic nervous system and after many trials on cadavers.

(6) Peri-arterial sympathectomy is not supported on anatomic and physiologic grounds and is a poor substitute for interruption of the gangliated cord and rami.

(7) With our present technic, it is impossible to interrupt all sympathetic nerves to an extremity without interrupting sympathetic nerves to other parts of the body, *e.g.*, blocking the sympathetic nerves to the arm produces a Horner's syndrome and also blocks some of the sympathetic pathways to the organs of the chest. Blocking the sympathetic nerves to a lower extremity also interrupts sympathetic fibers to certain lower abdominal and pelvic viscera. Therefore, one must decide whether or not the good primary effects desired are valuable enough to warrant producing the undesired secondary effects. A study of the secondary or associated physiologic effects adds to our knowledge of the autonomic nervous system.

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THE USE OF AVERTIN (TRI-BROM-ETHANOL) IN NEUROSURGERY

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ANESTHESIA in neurosurgery is one of the most important factors to be considered if one is to gain adequate and unhampered exposure of various regions of the brain. A "slack" brain need seldom be damaged in gaining access to most tumors or structures. A tense, edematous brain is usually damaged to some degree. The proper use of avertin (tri-brom-ethanol), we feel, as an adjunct to novocaine and ether anesthesia favors, in no small degree, the chances of being able to work without undue intracranial tension.

Our experiences with the drug in some 250 cases have impressed us with certain details regarding dosage in relationship to various lesions of the brain which may be of use to others. About 40 per cent of our cases did not require ether in addition to avertin and when the use of ether was necessary the amount was greatly reduced. The juvenile or apprehensive adult patient may be given the drug in his room and the operation started without crying, struggle, or cough with the subsequent heightening of intracranial pressure. Postoperative nausea and vomiting seem less where the decreased amounts of ether have been used. Postoperative vomiting is almost nil where novocaine and avertin alone are used. The alterations in pulse and blood pressure have seldom been of serious moment when the smaller dosages of avertin were employed. A certain fall in blood pressure usually occurs, however. Among the disadvantages of using avertin are the fact that its effect cannot be terminated at will. Ephedrine and coramine have been used with some success in this regard (Raginski,[29] Bourne,[11] Wood[41]). It is also quite impossible to predict the degree of narcosis that any given patient will have. Two patients of similar weight, age, adiposity and with similar lesions of the nervous system may experience quite variable depths of narcosis. For this reason the drug is often given in divided doses. Experience has shown that the very old or the very debilitated patient does not tolerate the drug well in usual doses. However, it may be used in people of the sixth decade or over without harmful effects if the above-mentioned precaution is heeded.

Method of Administration and Dosage of Avertin.—Avertin is used either in the crystalline form or as avertin fluid (dissolved in amylene). As a rule the drug is used in a 3 per cent solution, given per rectum. The doses originally recommended, 100–150 mg. per Kg. of body weight, are considered

too high for routine use in neurosurgical procedures unless given in divided doses. If little effect from 30 to 50 mg. per Kg. is noted after some 15 to 20 minutes the remainder may be safely given as a rule. It has been our practice to give 70 mg. per Kg. of body weight as an average total dose.

Bourne uses dosages from 125 to 150 mg. and has reported 1,000 cases without death, the proportion of the cases having a complete narcosis being 30 per cent. Saklad[32] uses 130 mg. per Kg. divided in order to give 70 mg. first, the rest being given in five to ten minutes. Watter[40] uses dosages extending from 60 to 120 mg. per Kg. securing complete narcosis in 54 to 60 percentage of instances. Stumpf[38] gives between 70 to 90 mg. per Kg. Field[20] advises 80 to 100 mg. per Kg. and indicates that the doses varying from 60 to 70 mg. per Kg. are the safest. Dott[18] uses 100 mg. for neurologic procedures. Kreuter[27] gives 100 to 150 mg. The concentration of the avertin in the rectal tap varies between 2 and 3 per cent. The principle and well-known danger of the use of avertin lies in respiratory failure of which Anschütz[1] has made a very thorough study. From his study he concludes that deaths in most of the cases are accidents of mechanical origin. There is an early relaxation of the jaw and pharyngeal musculature permitting the tongue to fall back and obstruct the respiration. Such accidents could have been prevented by a careful observation of the patient, keeping them on their side or by the judicious use of an airway. The intravenous administration of the drug advised by Kirschner[26] is of limited use and for short narcoses only.

Sebening,[36] Anschütz[2] and Gyllensvärd[24] have noted both experimentally and clinically that the drug is absorbed in adipose and nervous tissues more rapidly than elsewhere. These tissues also give up the drug more slowly than others. It is a commonly noted fact that an adipose individual will tolerate a higher dose of the drug than an emaciated one of the same weight.

Avertin and Neurosurgery.—Only a few references on the use of avertin anesthesia in neurosurgery are available. Of the cases reported many are those of avertin anesthesia used for diagnostic procedures only. No mention is made of neurosurgery by Goldschmidt and Harvey[22] in their study of the American literature. In 1927, Kreuter[27] advised its use in neurosurgery at dosages of 100 to 150 mg., the total amount being 10 to 12 Gm., with the concentration of the rectal tap at 3 per cent. Borchardt[10] thought avertins use in neurosurgery inadvisable. Schulze[34] used avertin in cases necessitating burr holes or bone flaps, mixing it with magnesium sulphate and adding narkophin. Rothig[31] did not advise its use because of a depression of the respiratory center and consequently a state of hypoventilation. In their monograph Anschütz, Specht and Tiemann[3] state that the use of avertin in neurosurgery constitutes an important progress. Dandy[16] prefers avertin to ether which he believes is associated with swelling of the brain and postoperative vomiting, a factor favoring postoperative pneumonia. He gives dosages varying from 60 to 100 mg., usually 90 to 95 mg. It is his opinion that the use of avertin is most advantageous for exposure of cerebellar

lesions, the pituitary region and other basilar areas. Goldschmidt and Hunt[23] reported 314 narcoses performed on 225 patients. In their series, there were 19 neurosurgical operations. These authors gave doses of 80 to 100 mg. per Kg. of body weight at a concentration of 2.5 per cent. In 24 per cent of their cases complete narcosis was obtained, and in 20 per cent this basal anesthesia had to be supplemented. They noted an average blood pressure fall (systolic) of 24 points and reported one case of death following a ventricular puncture where the dose of avertin used was 100 mg. per Kg. of body weight, and a total dosage of 7.3 Gm. No postmortem examination was made. Dott[18] uses 100 mg. per Kg. plus omnopon and hyoscine. Field and Pilcher, in using dosages of 80 to 100 mg. plus N_2O and ether, reported a 50 per cent reduction in the number of pulmonary complications with the diminution of postoperative headaches. Hadfield[25] uses avertin combined with a local anesthesia, the one having a synergetic action on the other. Bogan[8] reports using avertin in 907 cases. Of these 41 were neurosurgical cases. There were seven deaths for which the drug could not be held responsible. Wood,[42] using a dosage of 90 mg. per Kg. plus hyoscine, reports very good results. Davidoff[17] also uses 70 mg. of avertin for women and 80 mg. for men, but administers it only after local anesthesia has been given. Cushing[14] has used avertin per rectum with highly satisfactory results in patients who may be intolerant of local anesthesia alone. On the contrary, Bailey[5] is opposed to the use of avertin because of its depressing effect on the blood pressure and the nervous system, the imperfect narcosis obtained at times, and the lack of muscular relaxation. He states that the pulmonary complications in neurosurgery are rare with any anesthesia used.

Technic.—Before going over the report of our cases, we will state the technic generally used in this hospital. On the day prior to operation the patient is placed on a liquid diet. An enema is given during the evening before operation. After the patient has been brought to the operating room, the blood pressure and pulse are recorded over a short period of time. At times, particularly with children, the patient is not shaved until after the avertin has been given. The avertin is given on the division to children who are known to be fearful or apprehensive. The avertin fluid is mixed with freshly distilled water to make a 3 per cent solution, the avertin being added to the water already heated to at least 38° C. and not over 42° C. After thoroughly shaking, the solution is tested with Congo red. If a change in color is not seen (that is, if no acidity is present), the solution is given per rectum. As stated elsewhere, the dose of 70 mg. per Kg. is given in two parts when dealing with lesions of the third or fourth ventricle or in debilitated subjects. Large vigorous subjects are given morphia (Gm. 0.010–Gm. 0.015) after coming to the operating room. This also is given in divided doses at times. The patient is then watched carefully, the blood pressure and pulse being recorded every two to three minutes along with any respiratory changes. A local anesthesia is then given for the major operations. If, during the infiltration of novocaine the patient becomes restless or seems

about to awaken, ether vapor is usually given for a short time. It has been found by experience that a short ether anesthesia given soon after avertin is administered may obviate a much longer one if its administration is delayed until the patient is actually awake.

Statistical Résumé.—Two hundred and fifty consecutive anesthesias given on the neurosurgical service have been studied. Our inquiry is necessarily a clinical one and results recorded are, therefore, in part, "impressions." The degree of postoperative vomiting following the use of avertin as compared with ether is an example of this. It must also be borne in mind that this is not a study of the use of avertin alone but rather of its use in conjunction with other drugs such as morphia, ether, novocaine and at times nitrous oxide. The beneficial or deleterious effects of the avertin cannot be accurately quantitated from figures alone. Again an "impression" has to be relied upon to a certain extent. The value of avertin as an anesthetic will first be considered and then its possible relationship to mortality, morbidity, and postoperative pneumonia. We also wish to consider the relationship of avertin to alterations in pulse, blood pressure and respiration. Experience has shown that patients with lesions in certain areas respond differently to avertin and this will be commented upon.

The following points have been recorded for each case: Sex, age, diagnosis, operation, preoperative drugs, weight, dosage per Kg. of body weight, total dosage, concentration of the solution, blood pressure at various times of the operation, pulse rate changes, supplementary anesthetic, quality of the narcosis, and probable postoperative deaths.

We shall use the distinctive qualifications of adequate "surgical narcosis" which does not need to be further defined; of "sufficient narcosis" which is one under which an operation was performed without much difficulty but yet without complete surgical narcosis, and "inadequate narcosis" meaning that the avertin would have had to be supplemented by either for a major procedure.

Group I.—Narcoses with Avertin Only

THIRTY-FOUR CASES

	Doses in mg. per Kg. of body weight							
	35	45	60	70	90	100	110	
Surgical narcosis: 26 cases	1	0	0	12	8	4	1	= 26
Sufficient narcosis: 3 cases	0	1	0	1	1	0	0	= 3
Inadequate narcosis: 5 cases	0	0	1	2	2	0	0	= 5

Of the 26 cases recorded as securing a "surgical narcosis" there were only two major procedures. The remainder were for dressings, encephalograms, exploratory burr holes, resection of peripheral nerves and débridements of wounds. One of the major procedures was a craniotomy with exploration of the third ventricle (100 mg. per Kg.). The other was for an old osteomyelitis of the skull with removal of a bone flap (100 mg. per Kg. of body weight).

As shown above the dosages have varied from 35 to 110 mg. per Kg. of body weight. The majority of the cases were given 70 to 90 mg. per Kg. of body weight (26 of 34 instances).

In the same group there were three instances of "sufficient narcosis" including two minor and one major operations (removal of a third ventricle tumor, the dosage being 35 mg. per Kg. of body weight).

Finally, five narcoses were considered "inadequate" with dosages of 60, 70 and 90 mg.

In this series of 34 cases four fatalities occurred. In later discussion it will be pointed out that avertin in all probability had no part in producing these deaths.

In trying to ascertain the factors contributing to an adequate "surgical narcosis" the preoperative medication was considered. Of 26 cases of "surgical narcosis" with avertin alone, 12 did not receive any preliminary medication and 14 received either luminal or morphia or both. The majority of unsuccessful narcoses occurred when a preoperative drug was not given. In the group of narcoses secured with luminal (0.1 to 0.2 Gm.) as a preoperative drug, there were three instances of "sufficient narcosis" and one "inadequate." Where morphine was used as a preoperative drug a working narcosis was secured in all instances. The usual dose of morphia was 0.010 Gm. for an adult.

Preoperative Medication

Thirty-four Cases with Avertin Alone

	Surgical Narcosis	Sufficient Narcosis	Inadequate Narcosis	
No preoperative drugs	12	2	4	= 18
Luminal	3	1	1	= 5
Morphine (0.005 to 0.015 Gm.)	8	0	0	= 8
Morphine plus luminal	3	0	0	= 3

Preoperative medication seemed to play a greater rôle in the successful use of avertin alone than the type of procedure, keeping in mind that most of the procedures were minor affairs.

GROUP II.—NARCOSES PRODUCED BY AVERTIN PLUS LOCAL ANESTHESIA

SIXTY-ONE CASES

	Doses in mg. per Kg. of Body Weight									
	30	35	45	60	70	80	90	100	110	
Surgical narcosis: 46 cases	1	2	0	1	18	5	15	3	1	= 46
Sufficient narcosis: 9 cases	0	4	0	0	3	0	1	1	0	= 9
Inadequate narcosis: 6 cases	0	0	0	0	5	0	1	0	0	= 6

The second group includes 61 procedures performed with avertin and local anesthesia, the latter having been given as a rule 10 to 15 minutes after the avertin had been given. Novocaine one per cent was used with addition of adrenalin (3 to 5 gtt. per 30 cc.).

Of the 61 narcoses in this group 46 have been considered "surgical" or 75 per cent. The percentage of "surgical narcosis" with avertin alone was 76 per cent. However, narcoses in this group have been used in more major procedures such as craniotomies,[25] subtemporal decompressions,[4] cerebellar exposures,[5] laminectomies,[1] and minor operations such as ventriculographies. In the same group there have been nine "sufficient narcoses." Eight of these have been for major operations. In four instances the dose was 35 mg., which might explain the lack of a "surgical narcosis." Finally, there have been six "insufficient" narcoses. In one instance the drug was expelled. In another the avertin was given in two doses some 30 minutes apart. We are unable to explain the failure to produce narcosis in the other four cases.

In this series of 61 cases 14 deaths occurred, of which one has to be related to the use of avertin; this instance will be referred to in detail in the mortality résumé.

As in the case of the group using avertin alone the quality of the narcosis seems definitely to depend upon the preoperative drugs used.

Preoperative Drugs Used with Avertin Plus Novocaine

	Surgical Narcosis	Sufficient Narcosis	Inadequate Narcosis
No preoperative drug	5 cases	1 case	2 cases
Morphine (0.005–0.015 Gm.)	22 cases	5 cases	1 case
Luminal (0.1–0.2 Gm.)	5 cases	1 case	1 case
Morphine plus luminal	14 cases	2 cases	2 cases
	46 cases	9 cases	6 cases

Combining Group I (34 cases) and Group II (61 cases) we have 38 per cent of the total in which the use of an inhalation anesthetic was not necessary. It is quite possible that by using larger dosages of avertin the percentage of "surgical narcoses" could have been increased beyond this. However, in the reported cases with doses as high as 130 mg. per Kg. of body weight, there still remained a considerable percentage of inadequate narcoses. The risks of such increased doses are such that we feel that they are quite contra-indicated.

The administration of the local anesthesia before giving avertin undoubtedly adds to the efficacy of avertin. However, this is not practical in children or apprehensive adults. Davidoff[17] and others have practiced giving avertin after the operation is well under way with novocaine anesthesia. In spite of all precautions there probably will always remain a certain percentage of cases refractory to the use of the drug alone plus novocaine. There is also surprising individual variation of the same patient to the same dosage given at different times. It has been our observation that a patient will take a lesser dose of avertin for a second stage craniotomy than a first although the factor of pain may be the same.

The remaining 155 narcoses are divided into three subgroups.

GROUP III.—(A) AVERTIN PLUS ETHER; (B) AVERTIN PLUS LOCAL PLUS ETHER; (C) AVERTIN PLUS N_2O PLUS O_2

ONE HUNDRED AND FIFTY-FIVE CASES

	Doses in mg. per Kg. of Body Weight						
(A) Avertin plus ether: 44 cases	35	60	70	80	90	100	
Slight amount of ether: 42 cases	1	3	14	5	7	12	= 42
Large amount of ether: 3 cases	0	0	0	0	0	2	= 2
(B) Avertin plus ether plus novocaine anesthesia: 95 cases							
Slight amount of ether: 95 cases	5	6	49	10	20	5	= 95
Large amount of ether: 0 cases	0	0	0	0	0	0	
(C) Avertin plus N_2O plus O_2: 16 cases	0	0	8	0	2	6	= 16
							155

These three subgroups represent to a certain extent failures of the avertin or avertin plus novocaine to produce a sufficient or surgical narcosis. However, even when the avertin failed to produce narcosis adequate for work, it did afford at least two distinct advantages. First the patients could be anesthetized with ether without the usual period of excitement or struggle. In the second place the amount of ether necessary to sustain the narcosis was markedly diminished. A large amount of ether was necessary but in two cases. It is our observation that when ether anesthesia is started shortly after the avertin has been given, the degree the blood pressure falls is less than otherwise. A short ether anesthesia is also a fairly effective means of elevating, in a measure at least, a lowered blood pressure.

Sixteen narcoses have been secured with avertin and N_2O plus O_2. This type of anesthesia has been used largely for encephalograms where it seemed more convenient to give a slight supplement of anesthetic in the form of a short N_2O narcosis rather than a complete ether anesthesia.

Preoperative drugs have been used in this group about the same as those used for the first two groups. In Group III, where ether plus avertin plus novocaine was used, there were three cases of death that were due in part at least, we feel, to the avertin.

MORTALITY RÉSUMÉ AND CRITIQUE

Among the 250 narcoses performed there have been 30 cases of death (12 per cent). These deaths may be divided into two groups. The first one includes the cases where the cause of the death is definitely without relation to the use of avertin as shown by the postoperative course or the postmortem examination. The second group includes the cases where avertin as a cause of death, in part at least, must be definitely considered.

GROUP I.—DEATHS WITHOUT RELATION TO USE OF AVERTIN

NINETEEN CASES

No. 34572—H. C., aged 20. Avertin 70 mg. (4.3 Gm.) 3 per cent solution. Luminal 0.2 Gm. 12 hours prior to operation. Morphia 0.005 Gm. just prior to use of avertin.

Ether vapor for 140 minutes. *Operation.*—Suboccipital craniotomy for acoustic neurinoma. In reflecting the dura from over the right cerebellar lobe a large anomalous vein running between the superior surface of the cerebellum and the dura was torn. In order to control this bleeding the greater part of the right cerebellar hemisphere had to be resected. The wound was then closed, leaving the tumor extirpation for the second stage. The patient died, however, some ten hours later. Autopsy gave evidence of considerable edema of the brain stem. There was a moderate-sized blood clot between the tumor and the brain stem. It was felt that death was due to the presence of blood about the brain stem, edema of the pons and medulla, and not to avertin.

No. 84661.—C. C., aged 14. Avertin 70 mg. Ether 10 to 15 minutes. *Diagnosis.*—Brain abscess suspect. *Operation.*—A burr hole exploration over the right and left cerebellar lobes was made upon a comatose patient suspected of having a brain abscess. Burr hole over the right occipital region. No evidence of an abscess was encountered. The right lateral ventricle was tapped and found to be dilated. Death occurred six days later. Postmortem examination revealed a tuberculous meningitis.

No. 12283.—A. M., aged 25. Avertin 90 mg. Morphia 0.010 Gm. *Operation.*—The posterior cistern was exposed and drained for meningitis (staphylococcus). The patient had been comatose for two to three days prior to operation. Death occurred some 24 hours after operation.

No. 86523.—S. O'C., aged 49. Avertin 70 mg. Luminal 0.2 Gm. 12 hours prior to operation. Morphia 0.010 Gm. just prior to operation for an acoustic neurinoma. Ether anesthesia for 280 minutes. *Operation.*—Subtotal enucleation of acoustic neurinoma, left. Death occurred during the latter part of the operation. A postmortem examination was not granted. It was thought that death was due to edema of the brain stem and respiratory failure.

No. 59649.—W. H., aged 4. Avertin 100 mg. Luminal 0.1 Gm. 12 hours prior to operation. Ether 180 minutes. *Operation.*—Suboccipital craniotomy for large cerebellar medulla blastoma invading brain stem. Death occurred during closure of wound. A postmortem examination was not permitted. It was felt that death was due to trauma to the pons in removing the tumor invading it rather than to the avertin.

No. 68409.—R. K., aged 6. This patient was found to have multiple metastatic pneumococcic brain abscesses mainly in the left frontal lobe. Death occurred five days after drainage of the fourth abscess from rupture of purulent material into the ventricle. Avertin anesthesia was given on four occasions. The last anesthesia consisted of avertin 100 mg. Luminal 0.015 Gm. was given 12 hours prior to operation. Death was obviously not due to avertin.

No. 91486.—B. S., aged 44. Avertin 70 mg. Luminal 0.2 Gm. 12 hours prior to operation. Ether 80 minutes. *Operation.*—Second-stage craniotomy for a very large meningioma of the right lateral ventricle arising from the choroid plexus and found to be extending out into the temporal lobe. The patient was conscious at the end of the operation, able to talk and swallow well. The next day she was also in excellent condition. During the third and fourth postoperative days the temperature rose and signs of bronchopneumonia developed. Death occurred on the sixth postoperative day. A reelevation of the bone flap was done on the fifth day under local, to be certain that we were not dealing with débris in the ventricle as well as pneumonia. Postmortem examination revealed a bilateral bronchopneumonia.

No. 90913.—G. U., aged 55. Avertin 70 mg., novocaine. Morphia 0.005 Gm. *Operation.*—A simple suboccipital decompression for a far advanced acoustic neurinoma with multiple cranial nerve palsies was carried out as a first-stage procedure. A small biopsy of a very vascular tumor was made. Death occurred four days later from a bronchopneumonia—evidently from aspiration of food and secretions. Autopsy obtained.

No. 61084.—G. R. H., aged 8. Avertin 70 mg. and novocaine. Ether 20 minutes. *Operation.*—Burr hole exploration over the right lobe of the cerebellum. Ventriculogram. Right subtemporal decompression. This patient had a long drawn out history of an infected mastoid. When seen by us he was comatose and presented the picture of a

high degree of intracranial tension. A cerebellar abscess was suspected. A burr hole exploration, however, failed to reveal the presence of an abscess. A ventriculogram showed dilated ventricles. A subtemporal decompression was done as a means of relief of intracranial tension. Death occurred four days later. No autopsy. Suspected diagnosis—inflammatory occlusion of the aqueduct of Sylvius.

No. 84161.—K. B., aged 8. Avertin 35 mg. and novocaine. *Operation.*—Craniotomy for large third ventricle tumor (astroblastoma) which had invaded the lateral ventricle. Death occurred four days later. Autopsy showed an invasion and occlusion of the aqueduct of Sylvius as well as an extensive third and lateral ventricle tumor.

No. 58889.—C. H., aged 48. Avertin 90 mg. and novocaine. *Operation.*—Drainage of brain abscess secondary to lung abscess. Death four days later. Autopsy showed a thrombosis of left middle and posterior cerebral arteries, large brain abscess and lung abscess.

No. 50399.—C. W., aged 13. Avertin 90 mg. *Operation.*—Drainage of one of several frontal lobe abscesses. Death 14 days later. Autopsy showed an extensive cerebritis and several undrained abscesses.

No. 58238.—M. F., aged 49. Avertin 85 mg., novocaine, luminal 0.2 Gm. 12 hours preoperatively. *Operation.*—Craniotomy for left temporoparietal glioblastoma in a hemiplegic individual. A large mass of tumor was removed to insure temporary relief of heightened intracranial pressure. Death occurred five days later of cerebral edema and bronchopneumonia (autopsy obtained).

No. 70056.—J. R., aged 3. Avertin 100 mg., ether 180 minutes, novocaine. *Operation.*—Extensive removal of a cerebellar medulla blastoma in a much debilitated subject. Death nine days later of lobar and bronchopneumonia. Autopsy obtained.

No. 95199.—G. S., aged 62. Avertin 70 mg. Morphia 0.010 Gm. Novocaine. *Operation.*—Craniotomy for extensive right temporoparietal oligodendroglioma in a semicomatose patient. Death occurred 17 days later. Autopsy showed a terminal bronchopneumonia and multiple small lung abscesses.

No. 96244.—D. H., aged 7. Avertin 70 mg. (partially expelled), novocaine, ether 100 minutes. *Operation.*—Subtotal enucleation of cerebellar medulloblastoma with seeding in subarachnoid bed. Death one month later from unrelieved intracranial tension. No autopsy.

No. 48809.—P. A., aged 49. Avertin 90 mg. Morphia 0.015 Gm., novocaine, ether 180 minutes. *Operation.*—Suboccipital decompression for suspected tumor. Death ten days later from staphylococcus meningitis (wound infection). Autopsy showed a small cystic pineal tumor.

No. 60763.—Z. M., aged 37. Avertin 75 mg., novocaine. *Operation.*—Second-stage operation for a temporal lobe meningioma. Death 14 days later from erysipelas of head, neck and trunk. Autopsy showed evidence of meningitis of a few hours' duration.

No. 82203.—A. G., aged 32. Avertin 50 mg., novocaine. Morphia 0.015 Gm. *Operation.*—Craniotomy for third ventricle tumor which was found to be invading the left frontal lobe also. Death 11 days later. Autopsy showed an extensive third ventricle tumor invading each frontal lobe. An internal hydrocephalus and cerebral edema was also noted at autopsy.

The cause of death in these 19 cases would seem to be due to other factors than the avertin. The majority of those patients died several days after the operative procedure. However, it seems worthy of comment that five (91486, 90913, 58238, 70056, 95199) deaths occurred with respiratory complications. In only one (91486), however, does it seem that the bronchopneumonia could be related to anesthesia (0.004 per cent for the entire series of 250 cases). The other four patients were either semicomatose on admission or presented difficulties in swallowing that might be followed by pneu-

monia regardless of an anesthetic. If one chooses to include all five cases in the list of postoperative pulmonary complications the percentage is 2 per cent.

The second group of fatal cases, 11 in number, will be reviewed with particular reference to the relationship of avertin to the cause of death.

Group II.—Deaths Having a Possible Relation to Use of Avertin
Eleven Cases

No. 81798.—D. L. J., male, aged 49. This patient was semicomatose at the start of a transfrontal craniotomy performed for the removal of an extensive extrasellar pituitary adenoma. Novocaine anesthesia having been inadequate for work, 2.9 Gm. of avertin (35 mg. per Kg. of body weight) (3 per cent) were given. A surgical narcosis was obtained; the patient did not recover consciousness following the operation and died after 18 hours. The postmortem examination revealed a chronic endocarditis with pulmonary embolism and infarction. The remaining pituitary adenoma was a large one extending well back into the interpeduncular region—compressing the upper pons. That avertin was a major contributing cause of death seems doubtful.

No. 50643.—F. P., male, aged 38. This patient was operated upon for the second time in four months for a very malignant type of meningioblastoma in the right frontal region. He died seven hours after avertin and novocaine anesthesia had been given (70 mg.) and one and a half hours after the completion of the operation. A marked drop in blood pressure occurred twice during the operation, necessitating two transfusions, the second of which did not have any effect on the pressure. A fall in blood pressure did not follow directly upon administering avertin. Preoperative medication consisted of sodium amytal 0.2 Gm. and codein 0.030 Gm. The cause of death in this case was undoubtedly due to a combination of an extensive invasive tumor, hemorrhage and the trauma of operation rather than avertin.

No. 59426.—C. MacV., female, aged 9. This patient was originally operated on in this clinic in April, 1932, for a cystic pituitary gland. It was thought that the cyst was traumatic in origin since all symptoms, ocular and metabolic, followed a fracture of the skull. A good deal of relief of headache and visual symptoms followed the evacuation of 12 to 15 cc. of fluid from the cyst. A violent wave of hyperthermia followed operation, during which the patient nearly succumbed.

Symptoms recurred by January, 1934. At a second operation the cyst was readily emptied again. Avertin 35 mg. per Kg. was used plus ether and novocaine anesthesia. Blood pressure dropped from 90 Mm. Hg. to 45 Mm. Hg. as the cyst was being emptied. Another severe wave of hyperthermia followed. Death occurred some seven hours after operation.

We cannot say that avertin may not have had a part in the production of hyperthermia. However, this seems unlikely. Untoward symptoms came on immediately after emptying the cyst. Avertin was given at the time of the first operation in 1932, but was expelled before any effect was noted. Ether and novocaine alone were therefore used at that time. A wave of hyperthermia followed. It would seem more likely that death occurred from a disturbance of hypothalamic functions associated with emptying the cyst rather than the avertin.

No. 51239.—H. M., female, aged 50. This patient was operated on for a large left olfactory groove meningioma. During the course of the operation the left anterior cerebral artery was injured. Death occurred eight hours after completion of the operation. The patient was given avertin (90 mg. per Kg. of body weight) which was partly expelled. No preoperative drugs were used. Ether vapor was used for 270 minutes as a supplement to avertin and novocaine. A postmortem examination showed an embolus in the left pulmonary artery coming from thrombi in the pelvic plexus. It also showed a clot about the hypothalamic region in the subdural space which was probably the chief cause of death.

No. 77103.—F. L., female, aged 43, was operated upon for a rather extensive tumor

of the right frontal lobe invading the corpus callosum. Avertin (70 mg. per Kg. of body weight) (3 per cent) was given without preoperative drugs. Ether narcosis was started before the anesthesia from avertin was complete and was given during 180 minutes out of 260. A severe drop of blood pressure occurred after 180 minutes. There had been but little loss of blood. The fall of blood pressure following the administration of avertin was 25 Mm. Hg. after 20 minutes and 40 Mm. Hg. after 60 minutes. Blood pressure returned to its previous value after 110 minutes. The patient remained semi-comatose for 48 hours and on the third postoperative day died with high temperature.

In this case the exact cause of death is uncertain. The tumor was an extensive one involving the corpus callosum. Postmortem examination showed a rather extensive cerebral edema.

No. 74022.—M. M., female, aged 2, presented a huge ependymoma of the left parietal region extending across the middle line into the right ventricle. This tumor was partly removed in a first stage operation following which, however, signs of increased intracranial pressure were not relieved and a second procedure was undertaken. Avertin (80 mg. Kg. per body weight) was given. A portion of the dose was expelled and anesthesia did not follow. 30 mg. per Kg. was then given in a second dose. Again no anesthesia resulted. Ether anesthesia was then given. The rate of the pulse and of the respiration increased rapidly. Cheyne-Stokes' type of respiration appeared. Death occurred 160 minutes after the beginning of the operation. Autopsy showed a tumor arising from the choroid plexus which had crossed the midline and was invading the opposite hemisphere. This picture does not correspond at all with what we know about avertin intoxication. Since the use of avertin did not produce even a light sleep it is doubtful if it could be a factor in this case.

No. 51656.—M. R., female, aged 43. This patient was operated upon for an acoustic neurinoma with a very satisfactory subtotal removal. Avertin 5.1 Gm. (100 mg. per Kg., 3 per cent) was given. Preoperative medication consisted of 0.10 Gm. luminal and 0.010 Gm. of morphine. A good narcosis was produced and ether was not necessary. Blood pressure fell slowly during operation from 110/80 to 75/60. Half an hour after the completion of the operation a severe fall of blood pressure occurred. A transfusion of 250 cc. of blood was given with a return of blood pressure to 100 Mm. of Hg. The patient was rather slow to regain consciousness but 36 hours after the operation was talking and taking fluids well. On the third day she became comatose and died on the fourth day with respiratory troubles (Cheyne-Stokes) and final respiratory failure. From inspection of the wound and lumbar puncture it did not seem likely that bleeding was a factor. A postmortem examination was not obtained and the exact cause of death is not known.

No. 42194.—J. H., male, aged 59. This patient died 20 hours after a craniotomy for an extensive right posterior temporal lobe glioma. He was given avertin (80 mg. per Kg.) and morphine 0.010 Gm. at 8:15 A.M. Only a slight narcosis resulted. The bone flap was turned down under novocaine anesthesia. Another 0.010 Gm. of morphine was then given, followed by ether vapor for 30 minutes while the tumor was being resected. He did not regain consciousness following the operation. Death occurred 20 hours later. The postmortem examination failed to disclose the cause of death. We believe it may have been associated with clipping the posterior cerebral artery. It is rather difficult to rule out the possibility of a correlation between the use of avertin and death in spite of the light narcosis produced by it.

No. 57105.—P. R., female, aged 17. This patient developed a marked hydrocephalus on the basis of a sarcomatosis of the meninges. A simple suboccipital decompression was performed following which the patient did fairly well for several hours. Death occurred from a sudden respiratory failure some five hours after operation. A postmortem examination failed to disclose any gross bleeding. A sarcomatosis of the meninges was demonstrated. Avertin was given (80 mg. per Kg., 3 per cent). No preoperative drugs were used. Ether vapor was necessary during the whole procedure, the avertin having pro-

duced an incomplete narcosis. The fact that the narcosis was incomplete and that the patient reacted after the operation seem to speak against a correlation between the avertin narcosis and death. On the other hand, as the death occurred in a rather short time after the operation with prevailing respiratory difficulty, it prevents us from ruling out the avertin as a contributing cause of death, especially since autopsy failed to show any other cause. Patients with sarcomatosis of the meninges, however, frequently suffer difficulties of respiration.

No. 61624.—J. R., male, aged 14. This patient was operated upon for a cerebellar medulloblastoma. Avertin (90 mg. per Kg., 3 per cent) was given. Preoperative drugs consisted in 0.09 Gm. of luminal 12 hours before operation. Morphia 0.008 Gm. was given shortly before the avertin and again as closure of the wound was started because of restlessness. Ether was not necessary. Novocaine was used as usual. During the operation respiration ceased twice. The pulse and the blood pressure, however, remained unchanged. Those incidents occurred while dealing with that part of the tumor closely associated with the medulla. During the five hours following the operation the respiration became progressively more difficult without corresponding changes in the blood pressure and pulse until shortly before death. A postmortem examination was not allowed. However, from operative findings we believe that the floor of the fourth ventricle was invaded by tumor. This plus the operative trauma was probably the chief cause of death, although the use of avertin cannot be entirely ruled out. It was also felt that he may have had too much morphine even though he was large for his age.

No. 92248.—C. McJ., male, aged 15. The last patient presented clinical signs of a cerebellar abscess. In order to verify this diagnosis an exploratory burr hole was made under local anesthesia over the right suboccipital region. The right lobe of the cerebellum was tapped three times without encountering an abscess. A cerebellar exposure was decided upon and started. Avertin (70 mg. per Kg., 3 per cent) was given producing a slight degree of narcosis. Luminal 0.1 Gm. had been given 12 hours previously. Ether was started 10 minutes after the avertin was given. The patient became cyanotic, the respiration irregular, the pulse rapid and the blood pressure rose from 135/80 to 150/80. The skin incision was closed. Oxygen was given with beneficial results. Respirations became rapid, and irregular. The pulse ranged from 130 to 150. Some 230 minutes after the avertin had been given the respiration ceased. The postmortem examination showed the presence of a marked leukocytic infiltration of the right half of the pons and the medulla oblongata. There were also small foci of necrosis and hemorrhage noted.

In this case we have undoubtedly to deal with an "avertin death." Respiratory difficulty began about 15 minutes after the drug had been given and continued until time of death some four hours later. The dose of avertin was small. However, it was probably too large in the light of the postmortem finding of an already embarrassed brain stem.

In summarizing the findings of this second group of patients we can say that the first seven cases died in all probability from causes other than the avertin narcosis. In the last four cases, however, it seems that the avertin may have been one of the factors in the cause of death. A résumé of these four cases is of interest.

In the first three of them there was an increase of pulse rate of ten beats per minute after the avertin was given. The above table seems to put two points in evidence: first, in three times out of four cases the lesion was located in the posterior fossa. Secondly, in two cases morphine was given twice during operation. Thirdly, the changes in the blood pressure were small and seemingly of little note as were changes in pulse rate. The percentage of fatalities relative to the use of avertin is 1.6 per cent, or four

SUMMARY OF LAST FOUR FATALITIES

Unit No.	Name	Age	Sex	Location of Tumor	Operation	Preop. Drugs	Dosage mg.	Dosage Total	Concentration	Blood Press. Fall	Ether	Novocaine 1%
42194	J. H.	59	M.	Rt. post. temp. lobe glioma	Craniotomy with subtotal removal of tumor	Morphine 0.010 Gm. twice	80 mg.	4.3 Gm.	3%	15 points after 10 min.	Yes	Yes
57105	P. R.	17	F.	Sarcomatosis of meninges	Subocciptial decompression	None	80 mg.	3.3 Gm.	3%	No fall	Yes	No
61624	J. R.	14	M.	Cerebellar medulloblastoma	Subtotal removal of tumor	Luminal 0.097 Gm. Morphine 0.008 Gm. twice	90 mg.	2.9 Gm.	3%	10 points after 20 min.	No	Yes
92248	C. McJ.	15	M.	Leukocytic infiltration of medulla	Exploratory burr holes	Luminal 0.1 Gm.	70 mg.	2.8 Gm.	3%	No fall	No	Yes

cases out of 250 narcoses. This is assuming that avertin played a major part in the fatality. In only one case, No. 92248, do we feel that this is entirely true (0.004 per cent). The mortality rate for the series of the 250 cases is 30 cases or 12 per cent.

The question of the relationship of avertin effect to location of the tumor has been considered. While the exact site of action of avertin may not be known, there is ample proof that it does act on the hypothalamus. White and Van Wagenen have also shown experimentally that it also acts on the brain stem. They likewise have evidence to show that the action of avertin on an injured brain or after resections of portions of the brain is greater than otherwise. A theory is postulated that where the function of the hypothalamus or brain stem is embarrassed by the presence of a tumor, the avertin effect on the intact portion is greater than otherwise and the clinical effects to be noted are more pronounced. It would therefore seem reasonable to argue that lesser doses of the drug are indicated where one is dealing with an embarrassed hypothalamic region or brain stem.

A review of our cases supports this theory. Among 54 tumors involving or neighboring on these structures the mortality was 22 plus per cent as compared with 12 plus per cent for the group as a whole. A part of this increase in mortality is undoubtedly associated with the location of the lesion, its extent, duration, and general condition of the patient. However, it is seen from the accompanying table that most of the deaths (10 out of 12) occurred when the higher dosages of avertin were used (70 to 100 mg. per Kg. of body weight). We feel that when lesions in or about the third or fourth ventricle are being attacked a preliminary dosage of 35 mg. of avertin per Kg. body weight is sufficient. Another 35 mg. may be given later if indicated.

LESIONS OF THIRD AND FOURTH VENTRICLES AND ADJOINING REGIONS WITH MORTALITY FIGURES AND AVERTIN DOSAGE

FIFTY-FOUR CASES

Location of the Lesion	Dosage of Avertin in mg.						
	35	45	50	70	80	90	100
Cerebellum, 21 cases	1	1	0	9	2	5	3
Deaths, 4 cases	0	0	0	1	0	1	2
Nervus acousticus, 10 cases	0	0	1	4	0	2	3
Deaths, 4 cases	0	0	0	3	0	0	1
Third ventricle, 8 cases	1	0	1	0	1	4	1
Death, 1 case	0	0	0	0	0	1	0
Fourth ventricle, 3 cases	0	0	0	1	0	0	2
Deaths, 0	0	0	0	0	0	0	0
Pituitary body, 10 cases	7	0	0	1	0	2	0
Deaths, 2 cases	2	0	0	0	0	0	0
Pons, 2 cases	0	0	0	1	1	0	0
Death, 1 case	0	0	0	1	0	0	0

DEGREE OF NARCOSIS OBTAINED BY USE OF AVERTIN IN LESIONS OF THE BRAIN STEM AND HYPOTHALAMIC REGION

FIFTY-FOUR CASES

Tumor Site	Dosage	Surgical Narcosis, Ether Unnecessary	Adequate Narcosis	Insufficient Narcosis	
Pituitary body	35	0	4	3	
	70	0	1	0	
	90	0	2	0	
Cerebellum	35	1	0	0	
	45	0	1	0	
	70	2	4	3	
	80–100	3	5	2	
Nervus acousticus	50	0	0	1	
	70	1	3	0	
	80–100	1	3	1	
Third ventricle	35	0	1	0	
	50	0	1	0	
	80–100	1	3	2	
Fourth ventricle	70	0	1	0	
	100	0	2	0	
Pons	70	0	1	0	
	80	0	1	0	
		9	33	12	= 54

The percentage of surgical and adequate narcoses obtained by the use of avertin in this group of cases is considerably higher than for the series as a whole. The percentage for this group of brain stem and hypothalamic lesions is 77 plus per cent. For the series as a whole it is 37 per cent—95 out of 250 cases.

If one groups the pituitary and third ventricle tumors together (18 cases) there are 13 instances of surgical and adequate narcoses observed, or 66 per cent. Grouping the lesions of the cerebellum, nervus acousticus, fourth ventricle and pons together (36 cases) there are 29 instances of surgical and adequate narcoses. In other words, avertin has a greater effect in producing narcosis when there is a lesion of the hypothalamic region or in the posterior fossa than it does for a group of heterogeneous lesions of the nervous system.

Changes in the Blood Pressure Associated with the Use of Avertin.—The inquiry regarding the changes of the blood pressure in our series concerns 232 anesthesias. We may divide them into two groups. In Group I are the cases where a fall of blood pressure did not occur or where it might even have been increased. In Group II are the cases in which a fall in the blood pressure did occur.

There are 59 cases in the first group (24.5 per cent). The percentage of patients obtaining narcosis without a fall in blood pressure is 55.9 per cent (33 cases). The percentage securing adequate narcosis is 28.8 per cent (17

cases). The percentage in which the avertin did not have any effect is 15.2 per cent (19 cases). If the two last groups are added together (26 cases) we note that there were 15 children (57.6 per cent).

The second group includes 173 cases. The degree of blood pressure fall following the administration of avertin is charted as follows:

Blood pressure fall of 10–20 points Hg.—62 cases—35.8%
20–30 points Hg.—60 cases—34.6%
30–40 points Hg.—24 cases—13.8%
40–50 points Hg.—10 cases— 5.6%
50–70 points Hg.—17 cases— 9.8%

The fall of the blood pressure usually takes place during the first 20 or 30 minutes after administration of the drug, starting most frequently before the lapse of ten minutes and rather quickly reaching its maximum. However, in a few cases we did observe a fall of blood pressure coming on after some 40 to 60 minutes and not related to bleeding. In a few other cases the blood pressure fell more or less progressively to a degree where administration of ephedrine or similar drugs seemed indicated. As a rule the blood pressure tends to gradually rise again after reaching its low point rather than to remain on a low plateau. Occasionally it regains its former level in about the same length of time it took to fall. These observations are true in those instances where a supplementary ether was not necessary as well as others. The use of adrenalin in the novocaine might explain a part of this curve although it has been observed where avertin alone has been used.

The 17 cases presenting the most marked falls in blood pressure—over 50 Mm. Hg.—are worthy of note. Eight of these were known to have abnormally high blood pressures to start with. Three were in individuals with moderately advanced arteriosclerosis and four were in individuals much debilitated and dehydrated.

While a precipitant drop in blood pressure may be alarming to the operator, we have never seen a fatality result from it. Operative procedures have been postponed because of it in one case (resection of the fifth nerve via extracerebellar route). In four instances an injection of ephedrine 0.050 Gm. subcutaneously was given, whereas in the remaining 13 cases the blood pressure returned to normal spontaneously.

Changes in the Pulse Rate Associated with Use of Avertin.—Two hundred forty anesthesias have been studied from this standpoint. In 84 there was noted an increase of the pulse rate of at least 10 points. In 53 cases a rise of 20 points was noted. This occurred during the 10 to 30 minutes following the introduction of the avertin. Together these two groups comprised 57 per cent of the total number. Twenty other cases presented an increase of 30 points in the same period of time. Curiously enough, these changes in pulse do not correspond as a rule with the variations of blood pressure mentioned previously. Many patients experienced both increased blood pressure and pulse rates simultaneously. Finally, 21 patients presented an increase of pulse rate of 40 points or more. The increase of pulse rate rarely amounted to 60 points and rarely occurred simultaneously with a marked fall of the blood pressure as one might expect. Changes in pulse

rate have been noted mostly in children (about 60 per cent) and also most often in cases of cerebellar tumor. The pulse rate of 16 patients did not change at all. Twenty-seven showed a fall of 10 to 20 points. This occurred simultaneously with an increasing of the blood pressure as a rule.

Finally, it is worthy of note that many patients did not present the same changes of pulse rate at the time of subsequent anesthesia even though performed under the same conditions.

Respiratory Changes Associated with Use of Avertin.—The frequency of the respiration was usually slightly increased following administration of this drug. An almost constant phenomenon is the decrease in the depth of respiration. This is seen to appear simultaneously with the appearance of a slight cyanosis which is quite typical for the avertin. The shallowness of respiration at times prolongs the induction period of ether narcosis.

SUMMARY

The ideal anesthetic for neurosurgical operations is probably novocaine. However, there are a considerable number of instances where novocaine alone can not be used. In these cases the use of avertin (tri-brom-ethanol), supplemented with ether when necessary, is of real value. The use of this drug decreases quite materially the amount of ether necessary. The swelling of brain associated with crying or struggling or coughing is largely obviated. Capillary bleeding is lessened with the fall in blood pressure that often accompanies its use. The lessened swelling of the brain associated with the diminished amount of ether used allows a more unhampered exposure of various regions of the brain, particularly the regions of the base of the skull.

There are certain cautions, however, which may well be heeded in the use of avertin. Whenever the functions of centers in the brain stem are embarrassed by the presence of a tumor a lessened dose of the drug seems indicated. Our practice has been to give 35 mg. per Kg. of body weight in such cases and follow this in 20 minutes by a similar dose if necessary. The same caution holds, but to a lesser degree, where the tumor is situated in or about the third ventricle. It has also been our experience that avertin has a greater effect upon the injured nervous system than otherwise, and consequently a lessened dosage may be in order. This also holds for certain secondary craniotomies where portions of the brain have been resected at a first stage operation.

In the series of 250 anesthetics, 34 operations were performed under avertin alone. Most of these operations were of a minor nature. Sixty-one operations of a major nature were performed under novocaine plus avertin anesthesia. Groups I and II comprise 38 per cent of the total. One hundred fifty-five cases required the use of ether or nitrous oxide anesthesia plus novocaine and avertin. The use of morphia as a preanesthetic drug seemed to be the most important factor in assuring a physiologic effect of the drug. Pain will very often counteract the effect of ordinary doses of the drug. This is seen in instances of trifacial neuralgia or severe headache.

There were 30 deaths in the 250 cases. Of these one was considered definitely as due to avertin. Three others were considered as possibly having

at least some part in the cause of death. Three of these four cases had posterior fossa lesions. In two of the four cases two doses of morphia were given instead of the usual one. There were five cases in which pulmonary complications were of serious nature. In only one case, however, does it seem that this complication was related to anesthesia.

Alterations in pulse, respiration, and blood pressure following administration of the drug occur in a considerable number of cases. However, an operation had to be delayed in only one case because of these factors. A fall of blood pressure usually is accompanied by a satisfactory physiologic effect.

While we cannot give figures to show that the number of instances of postoperative vomiting are less than after a similar number of ether anesthesias, it is our very distinct impression that this is so.

The dose of avertin considered as optimum for neurosurgical operations is 70 to 90 mg. per Kg. of body weight. This may well be preceded by a five to ten mg. of morphia.

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TUMORS OF THE CAROTID BODY*

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TUMORS of the carotid body are rare, their diagnosis is difficult, and certain pathologic problems are unsettled. The surgical extirpation of these growths is always a delicate operation, never exactly easy, while often it assumes most formidable proportions. The postoperative mortality is high and the postoperative morbidity is considerable.

That such tumors are uncommon is shown by the fact that a cursory review of the literature reveals only 230 cases. It is probable, however, that others have been overlooked or have not been reported. Bevan makes the statement that few surgeons have operated upon more than one, not many have operated upon two, and no surgeon has operated upon more than three cases. The records of some of our metropolitan hospitals show how infrequently this condition is encountered: Manhattan Eye, Ear and Throat Hospital, one case; Mount Sinai Hospital, two cases; New York Hospital, two cases; Post-Graduate Hospital, five cases; Presbyterian Hospital, two cases; St. Luke's Hospital, two cases; St. Vincent's Hospital, two cases; Babies', Bellevue, Knickerbocker, Lenox Hill, Memorial, Nursery and Child's and Roosevelt Hospitals, no cases.

Historically, it is of interest to note that the first anatomic description of the carotid body was made by Von Haller, in 1743; that Luschka gave the first microscopic picture of its structure, in 1862; that Marchand described the first recognized tumor of the carotid body, operated upon by Reigner, in 1880; and that Middleton, in 1895, was the first American surgeon to operate upon a case. Scattered throughout the literature are isolated case reports. Keen and Funke, in 1906, and Bevan and McCarthy, in 1929, published admirable articles on this subject, with complete surveys of the literature. Another interesting contribution was that of Rankin and Wellbrock, in 1931, with a record of 12 cases, from the Mayo Clinic, the largest group ever reported from a single institution.

As no one surgeon, radiologist, or pathologist has, from his own experience, encountered a sufficient number of cases of carotid body tumors to be able to offer authoritative advice on the subject of their general management, it seemed that the study of a group of cases, even though it is not large, might be profitable. An effort has been made to put on record all the cases operated upon by members of the New York Surgical Society, and incidentally, to include the cases seen at the New York Post-Graduate Hospital,

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where this study was made. We have been able to collect 18 cases for this report.

CASE REPORTS FROM MEMBERS OF THE NEW YORK SURGICAL SOCIETY

CASE I.—Dr. Howard Lilienthal, 1906. Female, aged 38 years, had a tumor ten months. First operation was only a biopsy; later one-half of tumor was removed. No clinical diagnosis was made but the pathologic diagnosis was perithelial hemangioma. The growth recurred but there were no metastases. Death took place nine months later from repeated hemorrhage and cachexia.

CASE II.—Dr. William B. Coley, 1906. Male, aged 53 years, had a tumor six years. The facial nerve was ligated. The pathologic diagnosis was mixed cell sarcoma of the carotid gland. Patient recovered from operation but died from recurrence in eight months.

CASE III.—Drs. William B. Coley and William A. Downes, 1909. Male, aged 35 years, had a tumor four months. The external carotid and some branches were ligated. The pathologic diagnosis was malignant carotid gland tumor. There was a prompt recurrence and death occurred in four months.

CASE IV.—Dr. John Douglas, 1909. Female, aged 23 years. No arteries or nerves were injured. A clinical diagnosis of tuberculous adenitis was made but pathologic examination showed perithelioma. Patient recovered but had a temporary paralysis of the vocal cord.

CASE V.—Dr. Howard Lilienthal, 1909. Female, aged 56 years, had a tumor 30 years. All carotids and the internal jugular were ligated. Clinical diagnosis was carotid tumor. The pathologic diagnosis was malignant perithelial hemangioma. Patient had a temporary aphasia and hemiplegia. She was cachectic for three years and death occurred four years after operation.

CASE VI.—Dr. Frank Mathews, 1911. Male, aged 25 years, had a tumor three years. The external jugular vein was ligated. No clinical diagnosis was made but the operative diagnosis was carotid tumor. The pathologic diagnosis also was carotid body tumor (Callison). The growth was not removed, as it would have necessitated the ligation of the common carotid artery. Patient alive in 1914. Died about a year later, the "process having traveled upward toward the base of the skull." In a communication from Doctor Mathews, of August 27, 1935, he says that "this is my only carotid body tumor which has proven really actively and clinically malignant."

CASE VII.—Dr. W. S. Schley, 1916. Male, aged 37 years, had a tumor 20 years. All carotids were ligated but no nerves were injured. No clinical diagnosis was made but the pathologic diagnosis was carotid gland tumor. Patient recovered but there was temporary hoarseness.

CASE VIII.—Dr. Joseph Wiener, 1918. Female, aged 37 years, had tumor eight years. All carotids and internal jugular were ligated. No clinical diagnosis was made but pathologic diagnosis was perithelioma of the carotid gland. Tumor was considered to be malignant. Patient recovered. Had a partial right hemiplegia, right facial paresis, and also paralysis of vocal cord. She was given roentgen ray treatment after operation. No recurrence was noted four months later. Doctor Wiener states in a recent communication that the patient was lost sight of, so the final result cannot be given.

CASE IX.—Dr. Franz Torek, 1921. Female, aged 49 years. Tumor present for five years. Clinical diagnosis, aneurysm. Operative diagnosis, carotid body tumor. The internal jugular vein was resected. Carotid vessels not ligated in removing growth. Morbidity: Slight adductor paralysis which lasted three months. Patient recovered and remained well.

CASE X.—Dr. Charles E. Farr, June, 1923. Female, aged 27 years, had tumor for three or four years. Clinical diagnosis, tuberculous node; pathologic diagnosis, perithelioma of carotid gland, of low grade malignancy. Operation was difficult and

bloody. The carotid vessels did not have to be ligated. Recovery was uneventful. Patient received roentgen ray treatment and remained well for several years, and then was lost track of.

CASE XI.—Dr. Frank Mathews, March, 1928. Male, aged 45 years. Clinical diagnosis, not given; pathologic diagnosis, tumor of the carotid body. The removal of the growth was incomplete and fragmentary, because of unwillingness to perform a carotid ligation. The tumor has slowly enlarged and is now the size of a walnut, but the patient is quite well.

CASE XII.—Dr. Edward W. Peterson. Female, aged 27 years, entered the Post-Graduate Hospital September 30, 1929. She had a tumor about the size of an English walnut, which had been present for six years. It was situated on the right side, under the sternocleidomastoid muscle, in the upper anterior cervical triangle. It was a small nodule for over five years, but between April and September it grew rapidly. It was painless and could be moved from side to side, but not up and down. Pulsation was not at all marked. There were no other symptoms except the increasing deformity caused by the growth. The clinical diagnosis was carotid body tumor, and the rapid growth suggested possible malignant change; the pathologic diagnosis was malignant perithelioma of the carotid gland. At operation October 1, 1929, the tumor was found to saddle and envelop the common carotid artery and its external and internal branches completely. A painstaking effort was made to dissect the growth from the carotids, but during the attempt, hemorrhage so profuse and uncontrollable from the substance of the tumor was encountered that it became necessary to ligate the common carotid artery. The operation was completed without further difficulty. Six hours later the patient appeared to be reacting normally. Four hours later, however, she developed a complete hemiplegia of the left side.

Two months later the physical examination showed a complete left hemiplegia, following operation for the removal of a malignant carotid body tumor. Increased hyperreflexia, left greater than right. Bilateral Babinski. Unilateral (left) Hoffman. Questionable impairment of light touch, pain and joint-muscle sense. Asteriognosis, left. Bone conduction referred to right. Tongue protrudes to left. Fundi normal. Emotional reaction—irritable, defensive, suspicious. Cooperates poorly. *Orthopedic Diagnosis.*—(1) Wrist drop, left; paralysis of arm (?) complete. (2) Equinovarus, left foot; paralysis of muscles below knee. At present the patient's general health is excellent. She walks with the aid of a cane. Her left arm is still practically useless. There has been no recurrence of the growth.

CASE XIII.—Dr. John M. Hanford, December, 1931. Male, aged 26 years, with history of tumor of left side of neck of four years' duration. Clinical diagnosis, tuberculosis of the upper deep cervical nodes. Pathologic diagnosis, paraganglioma of the carotid body. External carotid artery ligated. No nerve injury. Prompt recovery and patient has remained well.

CASE XIV.—Dr. John M. Hanford, September, 1934. Male, aged 26 years. Tumor in left side of neck for two years. Clinical diagnosis, tuberculous lymph nodes. Pathologic diagnosis, paraganglioma of the carotid body, not thought to be malignant. At operation the tumor so surrounded the carotid vessels that all three carotid vessels had to be ligated in order to remove it. The left hypoglossal nerve was divided, but reunited. After operation there was no brain damage—"probably because there had occurred a very gradual compression of the carotid arteries by the tumor." There was partial tongue paralysis and also trapezius muscle paralysis, due to spinal accessory nerve trauma during the operation. Follow up by letter, September, 1935, finds the patient in good condition.

CASE XV.—Dr. Edward W. Peterson. Female, aged 47 years, entered the Post-Graduate Hospital, May, 1935. She had had a tumor in the upper left anterior triangle of the neck for eight years. A tonsillectomy operation four years before had no effect

on the growth. In 1932, she was operated upon for a tuberculous anal fistula. In 1933, an unsuccessful attempt was made by another surgeon to remove the neck growth —the operation being stopped before the tumor was actually uncovered and its location and character determined. At the time of admission to the hospital she did not complain of any symptoms due to the presence of the neck tumor. It was quite noticeable, how-

FIG. 1A.—(Path. 63892, Doctor Peterson's second case.) "Potato tumor." XI.I (enlarged ½).

FIG. 1B.—(Path. 24746, Doctor Sheehan.) Tumor removed from parotid region. XI.I (enlarged ½).

ever, and she wished to have this deformity remedied. It was rather fixed from the previous operation, and showed slight lateral mobility, but none up and down. There was pulsation, but it was not striking. The clinical diagnosis was tuberculous nodes. At operation, as soon as the skin and platysma had been incised, a plexiform mass of vessels large and small was encountered. At this stage, it was thought that we were

FIG. 2A.—(Path. 63892.) The cut surfaces are similar. XI.I.

FIG. 2B.—(Path. 24746.) The cut surfaces are similar. XI.I.

dealing with an angiomatous mass, around a carotid aneurysm. It was necessary to ligate a great many vessels before the actual tumor was uncovered and recognized as originating in the carotid body. The operation throughout was a delicate and most difficult one. The tumor so involved the common carotid below the bifurcation that this vessel was isolated and a tape placed around it. In view of the disastrous train of symptoms that had followed ligation in our other case, it was determined to abandon the operation rather than to subject the patient to this risk. The tumor was dis-

sected from the common carotid artery. It was found necessary to ligate the external vessel in order to mobilize the growth. Then followed a most careful dissection of the internal carotid artery. This was accomplished and the tumor removed. At two points, however, where vessels were apparently given off from the internal carotid to the carotid gland, there were wounds of this vessel. An attempt to repair this damage with fine Chinese silk left us so much in fear of secondary hemorrhage that the common carotid artery was ligated. Fortunately, there followed no evidence of brain damage, and the patient made a good recovery. There was temporary hoarseness, drooping at the left angle of the mouth, and some interference with motion in the left side of the tongue, but these evidences of nerve damage cleared up rapidly. The patient is now quite well.

Pathologic Report (63892).—Dr. W. J. MacNeal.—*Gross.*—Specimen measures 51 by 36 by 27 Mm. On section it presents a well defined capsule about 1/2 Mm. in thickness. Internal to this there is firm, slightly opaque fleshy tissue which is light pink in color where it has not been fixed. The appearance suggests altered thyroid gland (Figs. 1A and 2A).

Microscopic.—Sections show a rather thin fibrous capsule from which slender strands extend into the interior. These carry fairly large blood vessels but there are also some rather broad bands of connective tissue. The remaining mass is made up of irregular nests of polyhedral cells (Fig. 5). These cells have round or oval nuclei which are somewhat variable in size and in intensity of staining. The cells themselves are fairly large, the cytoplasm stains pink with eosin and presents a finely granular appearance (Fig. 6). The cells are variable in form. About these cell nests there are irregular blood spaces and capillaries which are in some places widely distended. There are also spindle shaped fibroblasts which appear to participate in the growth. In many places the tissue is poorly fixed and the cell nests are partly disintegrated. The mass is highly vascular everywhere. *Diagnosis.*—Tumor of the carotid body ("perithelioma of the carotid gland"). Note: These tumors are of rather slow growth, and although they may recur locally and even invade adjacent lymph nodes, they do not tend to form distant metastases.

OTHER CASES FROM THE NEW YORK POST-GRADUATE HOSPITAL

CASE A.—Dr. Neal Macphater, 1903. Female, aged 34 years, had a tumor of neck for six years. No clinical diagnosis was made; operative diagnosis, carotid body tumor; no pathologic examination was made, so the type of tumor was not determined. All carotids and internal jugular vein were ligated. Recovery without evidence of cerebral anemia or other complications.

CASE B.—Doctors Cahill and Taylor, 1916. Female, aged 52 years, had a neck tumor for eight years. No symptoms of any moment. No preoperative clinical diagnosis; pathologic diagnosis, tumor of the carotid body. Not necessary to ligate any carotid vessels, but the internal jugular vein had to be resected. Hypoglossal nerve stretched and somewhat traumatized. Temporary paralysis of tongue and dysphagia developed. Complete recovery.

CASE C.—Doctors Sheehan and Rabiner, 1925 (Figs. 1B and 2B). Female, aged 50 years, had tumor two years. No major ligations required. Clinical diagnosis, aneurysm of the facial artery. Pathologic diagnosis, carotid body tumor. Temporary paralysis of submaxillary branch of facial nerve (drooping of angle of mouth), and temporary drooping of upper eyelid. Patient was given roentgen ray treatment after operation. Good recovery.

ANALYSIS OF CASES

There were 11 females and seven males, ranging in age from 25 to 56 years; average age, 38 years. The tumor had been present before operation

from four months to 30 years; average time, approximately six years. There were only two correct preoperative diagnoses. There were no operative deaths among our 18 collected cases. Pneumonia, hemorrhage, cerebral anemia and infection have been mentioned in the order of their importance as the causes of death. There were five deaths, however, from malignancy, occurring respectively nine months, eight months, four months, four years and four years after operation.

Total cases considered pathologically malignant, eight, or 44.4 per cent. In the Bevan-McCarthy review, there were 24 malignancies and recurrences, or 17.8 per cent; and in the Rankin-Wellbrock report, there were six malignancies out of 12 cases, or 50 per cent. One patient had bilateral carotid body tumors, with one growth malignant and the other benign. Thus, out of 13 specimens, six were malignant and seven benign, or 45 per cent malignant. Two of the cases returned to the Mayo Clinic later, with possible metastasis to the brain; one patient had symptoms of brain tumor, and the other of epilepsy, but these conditions were not verified by necropsy. Doctor Mathew's second case, where the tumor could not be completely removed, now has a recurrence the size of a walnut, but the patient is quite well otherwise, seven years after operation.

The total number of cases with common or all carotids ligated is seven, with no deaths. Bevan and McCarthy report 62 cases in this group, with 21 deaths—a mortality rate of 33.8 per cent; while Rankin and Wellbrock report three cases, all succumbing in the first 48 hours—a death rate of 100 per cent.

In our group of seven cases, four showed no evidence of brain damage following ligation of the common carotid artery; one had a temporary aphasia and hemiplegia; one had a partial right hemiplegia, right facial paralysis, and also paralysis of the vocal cord; and one had complete hemiplegia.

Total cases with postoperative disabilities—15, or 83.3 per cent. The morbidity ranged from slight, temporary paralysis to complete hemiplegia.

Symptoms and Diagnosis.—There are no symptoms or signs upon which the diagnosis of carotid body tumor can be made with certainty. Surgical dissection, best with aid of microscopic examination of the tissue, is necessary to settle the question definitely. Preoperative diagnosis appears to be difficult, for it has been made correctly in relatively few instances. It is believed, though, that this failure to make a tentative diagnosis is due to the fact that, tumors of the carotid body being rare and mimicking closely other more common growths, they are not even thought of. The clinical picture in the majority of cases reviewed seems to be rather uniform and characteristic. Usually there is a history of a single, smooth, deep seated, slow growing tumor in the upper cervical triangle, at the bifurcation of the common carotid artery; it may have been present for many years; it is usually painless—in fact, it gives rise to no symptoms at all, except the increasing deformity which accompanies its growth; it is not attached to overlying skin or muscles; it is ovoidal or rounded in shape; it is firm and elastic in charac-

ter—seldom soft or stony hard; it is movable laterally, but not vertically; in size, it may be as small as a hazelnut, or as large as a goose egg; it pulsates, but the pulsation is transmitted and not expansile, as in an aneurysm; rarely bruit and thrill may be present; compression of the common carotid artery below abolishes the pulsation, bruit and thrill, and often diminishes the size of the tumor. While the growth is practically always unilateral, Lund, Rankin and Wellbrock, de Tarnowski and Chase have reported examples of bilateral or probable bilateral tumors of the carotid body.

If other symptoms are present, they are due to pressure on the vagus, cervical sympathetic and recurrent laryngeal nerves, or upon neighboring structures, such as the tonsil, pharynx, esophagus, *etc.* Fainting spells, Stokes-Adams syndrome, hoarseness, cough, dilatation or constriction of the pupil, tinnitus aurium, headache, dysphagia, dyspnea, bulging of the pharyngeal wall, *etc.*, are symptoms that have been mentioned in the study of this subject.

Any growth, slow in its development, at or near the bifurcation of the common carotid artery, movable laterally, but not vertically, with transmitted, but nonexpansile pulsation, should be considered as a possible carotid body tumor. Carotid aneurysm, metastatic carcinoma, lymphoma, lymphosarcoma, tuberculous nodes, aberrant goiter, branchial cyst, branchiogenetic carcinoma, neurofibroma, ganglioneuroma, *etc.*, occurring in this region, may so closely simulate carotid body tumor as to make differential diagnosis difficult or impossible. Even at operation, certain growths which have been diagnosed as carotid body tumor have upon pathologic study proved to be something else. Microscopic examination alone can determine the true character of a suspected tumor.

Greene and Greene have suggested the use of the aspiration biopsy plan of Martin, or the punch biopsy method of Hoffman, in obtaining material for microscopic study in making a differential diagnosis in neck neoplasms. Other tumors of the neck, and also tumors of the breast, lung, bone, *etc.*, have been diagnosed by this plan. Certain growths, however, such as parotid or mixed salivary tumors, do not, we understand, lend themselves satisfactorily to this kind of study. It remains to be ascertained whether carotid body tumors can be recognized by this method. If, in the future, the pathologist can place a definite label on these growths before operation, and give an opinion as to malignancy or potential malignancy, then it follows that the surgeon will be able to lessen the high operative mortality and morbidity. Doctor MacNeal's comment, however, is: "Vascularity of these carotid tumors and the proximity to the carotid artery make one pause before trying aspiration or punch biopsy." Proper preliminary treatment might avert the danger of death from cerebral anemia and softening and avoid the serious major paralyses which so often follow ligation of the common or internal carotid arteries. Furthermore, there would be the opportunity of placing all the facts before an intelligent patient, so that due consideration could be given to the hazards

of surgical operation. The patient then could share with the surgeon some of the responsibilities.

Anatomy, Embryology and Pathology.—The recent literature contains 25 carotid tumors not included in the compilations of Bevan and McCarthy, 1929, and Rankin and Wellbrock, 1931. They have been reported from such widely separated localities as Canada, England, France, Italy, Scandinavia, South America, Africa, Russia, and Japan. Most of the authors have made case reports but a few have made elaborate studies and defined and emphasized certain points for consideration. We are referring in particular to the chromaffin cells and their relation to epinephrin, to the cells of the carotid

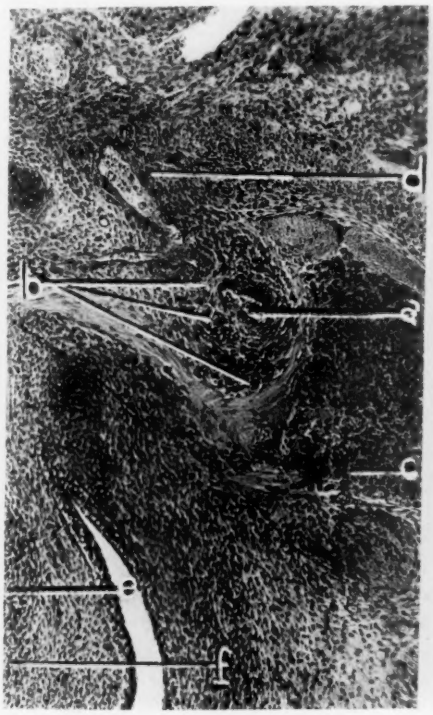

FIG. 3A.—Embryo "D," 45 days.

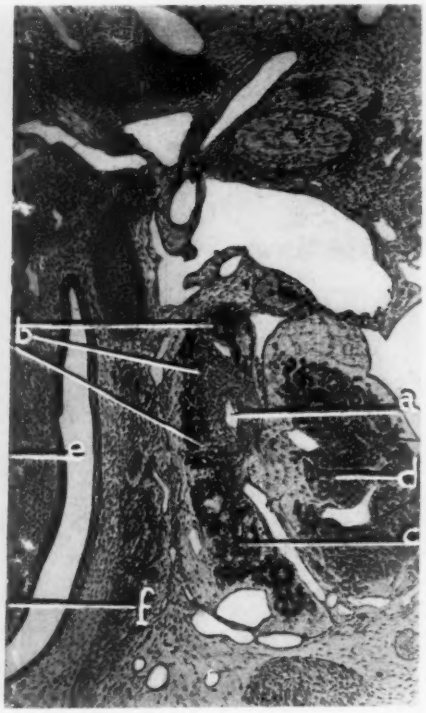

FIG. 3B.—Embryo, 44 days (Keibel and Mall). (a) Carotid artery; (b) carotid anlagen; (c) superior cervical ganglion; (d) ganglion of vagus; (e) pharynx; (f) muscle.

parenchyma and the distribution of the sympathetic nerve elements. Each investigator has realized that a definite understanding of these important features is needed to enable the internist, the surgeon, and the pathologist to appreciate and deal with these puzzling tumors.

We may, indeed, come to abandon the designation "tumor" for that of compensatory hyperplasia, suggested by Chase, as the embryology, anatomy, physiology and pathology are more precisely understood.

Embryologically, the derivation of the cells forming the "glomus caroticum" was considered: first, a budding from the epithelium of the pharynx

(Stiedé); second, from the endothelium or from the adventitia of the carotid artery (Paultauf, Waldeyer, Funke); third, from blood vessels (Marchand); and, fourth, from the embryonic ganglion cells of the sympathetic plexus (Kohn).

The present conception of their origin may be summed up as follows: They arise from the neural tube as sympathogonia, that is, primitive cells of the sympathetic system, and, after arriving at the carotid bifurcation, differentiate into sympathoblasts or into chromaffinoblasts and, still later, into sharply demarcated chromaffin and sympathetic ganglion cell masses, the paraganglia (Zuckerkandl). They may be found in embryos of 19 Mm. or six weeks (Fig. 3), and are fully developed at ten weeks. Instead of maturing as indicated, their development may be arrested at any stage. Funke dissected eight fetuses and found a carotid body in one only and that on one side. After birth they may remain primitive or regress. Da Costa states the gland is frequently absent and Funke agrees to this both for embryos and after puberty. This may account in part for the rare occurrence of carotid body tumors. Developmental steps in other paraganglia duplicate those of the carotid bodies, all of which belong to the same chromaffin system. The best known are the paraganglia of the abdominal aorta (Zuckerkandl).

Anatomically, the carotid bodies are situated at or near the bifurcation of the common carotid artery and are the largest of the paraganglia included in the chromaffin system. They vary in size from a hemp seed to a grain of rice, 2 to 5 Mm., and are yellowish-pink. They may be formed of several nodules connected to the carotid vessels. They are also intimately connected with the superior cervical ganglion, the vagus, the glossopharyngeal and superior laryngeal nerves. They possess a thin capsule and fibers extend inward forming septa, separating groups of parenchymal cells, the "cell-balls." Dissection and microscopic studies have disclosed varying numbers of chromaffin and sympathetic ganglion cells. The septa carry numerous blood vessels and nerves which branch and ramify abundantly. The cell nests are enclosed in thin-walled capillaries (Figs. 4, 5 and 6). Nerves enter the cell nests and break up into small varicose tendrils, with button-like ends (Fig. 7). According to Dietrich, the relation of the cells to the nerves is more intimate than to the blood vessels. Ganglion cells both in clumps or scattered are found in the capsule and occasionally in the interstitial tissue. Chase, and Bertrand and Sauvage in two recently published papers consider the nerve elements of more histologic value than the chromaffin cells. By special staining (Bielschowsky), it is possible to demonstrate specialized nerve fibrils in the cell nests as in paraganglia (Fig. 7). Throughout the literature it is notable that some investigators have found chromaffin cells in normal carotid bodies and in tumors and others have not. The latter statement is emphasized by Callison, Bevan and McCarthy, and recently by Chase and by Cragg. The significance of the chromaffin cells has been variously estimated. They are distinguished by granules in their cytoplasm that stain yellowish-brown with

chrome salts (Stilling), are positive for Vulpian's iron test and stain with osmic acid. The granules are considered as epinephrin granules (Kohn), as

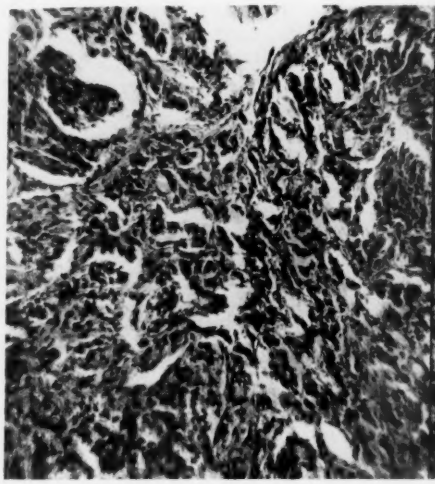

FIG. 4.—(Path. 41429, Doctor Peterson's first case.) High power photomicrograph showing cell nests and ramifying blood vessels. Paraganglioma (malignant?).

FIG. 5.—(Path. 63892, Doctor Peterson's third case.) High power photomicrograph showing cell nests and ramifying blood vessels. Paraganglioma.

precursors of epinephrin (Chase), as not related to epinephrin (De Castro). Miller, by special staining, identified epinephrin in the blood plasma.

In addition to histochemical reactions, extracts of the carotid bodies and

FIG. 6.—(Section of Fig. 5, at higher magnification.) Large polyhedral cells with granular cytoplasm forming the cell nests.

FIG. 7.—(Section of Fig. 5, at higher magnification.) A nerve fibril with button-like end is seen passing to the epithelium (Bielschowsky stain).

tumors have been injected into animals. Mulon produced a rise and Gomez a fall in blood pressure. The failure to find chromaffin granules or positive reactions for epinephrin indicates either that the granules are exhausted or

have no relation to epinephrin. This lack of relation is strongly supported by many, among them Nordmann and very recently Cragg.

We may sum up the contradictory evidence on carotid body tumors by several facts. Its inconstant presence, its atrophy at puberty, the questionable results of experimental work and the lack of definite symptomatology all indicate that the function of the carotid body is probably not important. That it has an internal secretion is now considered very doubtful.

In studying the tumors of the carotid bodies, it is necessary to consider tumors of other paraganglia of the chromaffin system. The literature con-

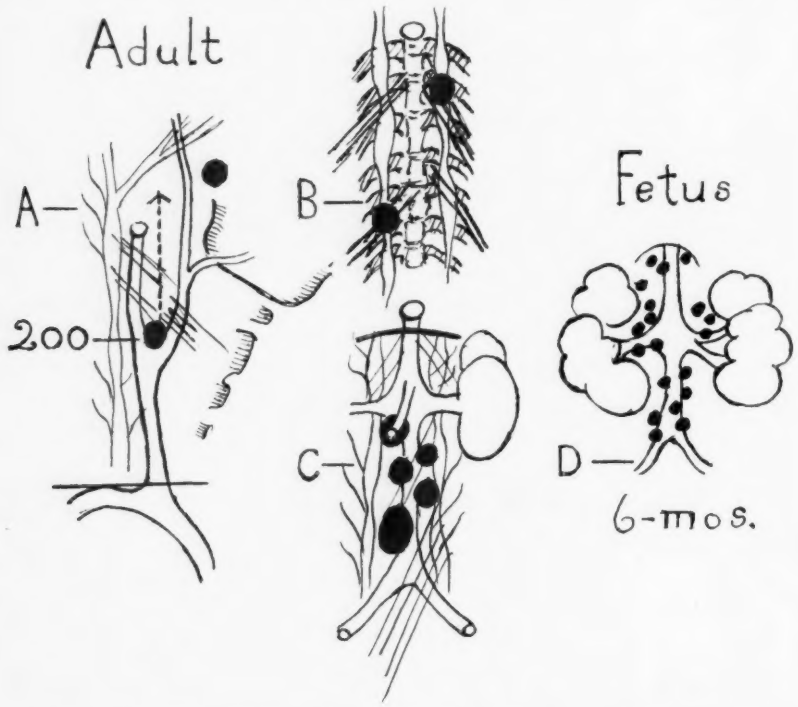

FIG. 8.—Schematic drawing. The black masses indicate paragangliomata. (A) 200 + located at the bifurcation of the carotid artery. (B) Thoracic paraganglioma between fourth and fifth, and ninth and tenth ribs. (C) Aortic paraganglioma (Zuckerk-andl). (D) Common distribution of chromaffin bodies in the fetus.

tains eight examples, Stangl, Hausmann and Getzowa, Miller, Handschin, Nordmann and Lebküchner, Lebküchner, and Cragg (Fig. 8). The first were isolated tumors but Cragg found coincident carotid and Zuckerkandl body tumors. Necropsies were performed, the histology studied, and chromaffin and epinephrin tests made. The findings, both positive and negative, duplicate those of carotid body tumors.

Grossly carotid tumors are similar and have been called "potato" tumors from their size and shape. Their color varies from pale gray to yellow to dark reddish-gray, the consistency varying largely with the blood supply.

Microscopically, there is more variation, and many names have been ap-

plied according to the cell differentiation, histologic details and interpretation of the findings. More than 90 per cent have a common histologic picture. They have been called carotid tumor and perithelioma for the most part. Some have been designated endothelioma and paraganglioma, a few angioma, angiosarcoma and neuroblastoma. Miller suggested sympathetic naveus or carcinoid. Paraganglioma is the present accepted term since paraganglionic elements have been repeatedly demonstrated (Miller, Chase, Cragg): namely, chromaffin, epinephrin, and sympathetic nerve terminals.

In Doctor Peterson's second case, the chromaffin reaction was faintly positive in peripheral portions and the nerve elements were characteristic. Tests for epinephrin were not made.

As regards the malignancy of the tumors of the paraganglia, the clinical course and histology do not always agree, as in Doctor Peterson's first case. Proof of malignancy has been doubted in some cases. The possibility that the carotid tumors are examples of compensatory hyperplasia has been suggested. The patients with carotid tumors are commonly without symptoms.

Comparisons of blood pressure before and after removal of the carotid tumor have not been recorded in sufficient numbers to aid our understanding. Necropsies are few and so dissections for possible anomalies, enlargements or atrophies of other paraganglia of the chromaffin system have not been adequately investigated.

The bilateral occurrence, the occasional tumors of the paraganglia duplicating the carotid body tumors, the rare familial incidence and the single example of coincident carotid and aortic paraganglioma suggest systemic or hereditary factors for their production.

These tumors are associated with the nerve elements of the sympathetic system and possibly occupy a position similar to the von Recklinghausen group of tumors.

Treatment.—There is among surgeons unanimity of opinion as to the ideal treatment of carotid body tumors. Early and complete removal, if it can be accomplished without the sacrifice of important blood vessels, is the method of choice. On the other hand, there is considerable difference of view as to the proper procedure if the tumor cannot be removed without ligation of the carotids. Ever since Keen, in 1906, advocated conservatism, after reciting the unfortunate outcome following carotid ligation in his only case, numerous writers have warned against radical surgery in the treatment of these cases. Bevan, in 1929, made an eloquent and convincing plea that "in the future, neoplasms of the carotid body should not be removed when it is necessary to ligate the carotid arteries in order to complete the operation." His case, subjected to an exploratory operation only, and later given roentgen ray treatment, recovered completely, and has remained well to date. This case is unique and such a recovery will not frequently be duplicated, for the records indicate that the great majority of cases treated by roentgen ray and radium have resulted in failure. Sullivan believes that treatment can only be surgical. Royster says that prompt recognition and early removal,

even at the expense of resection of important blood vessels, appears to be the only rational treatment.

How can the mortality of over 30 per cent and the incapacitating disabilities, so often present in surviving patients, be lowered? We are convinced that both mortality and morbidity can be reduced, and we offer the following suggestions: (1) That a clinical diagnosis can and should be made; (2) that every suspected case, unless urgency of symptoms forces quick action, should have systematic compression of the common carotid artery against the large anterior tubercle of the transverse process of the sixth cervical vertebra, several times a day for a few weeks, in order to develop collateral circulation in the brain on the affected side; (3) that the operation should be an exploratory one, and if the growth cannot be removed without ligation of the carotids, that a biopsy by the Hoffman punch method be made, to settle the question of possible malignancy, after which a temporary ligature or Halsted metal band be placed around the common carotid artery to determine the success or failure of the preliminary treatment aimed at establishing adequate collateral circulation and avoiding cerebral anemia and softening. Nothing further is done at this stage—the wound is closed, and developments are awaited. The ligature or band is to be removed at the first signs of hemiplegia. If the biopsy specimen shows evidence of malignancy, a decision must then be made as to whether radiation treatment or radical surgery will be employed. If, however, no symptoms of brain damage appear, a secondary operation can be performed and the complete removal of the neoplasm accomplished with but little risk.

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DISCUSSION.—DR. FRANK S. MATHEWS (New York) presented a patient operated upon nine years ago at the age of 58. There had been noted a tumor of the left side of the neck under the angle of the jaw, the size of a large hen's egg. Examination showed the left tonsil pressed far inward. There was some difficulty in breathing, especially during sleep. The tumor could not be displaced downward in the neck. Under rectal anesthesia the tumor was removed. A flap was raised over it including the platysma muscle. The tumor was definitely encapsulated. The hypoglossal nerve was stretched tightly across its surface. It lay between the external and internal carotid arteries, hence undoubtedly within the carotid sheath. It extended up under the jaw to the base of the skull. On reaching its capsule it was largely enucleated with the finger. The internal jugular vein was scarcely seen and was displaced far outward. There was no asymmetry of the pupils. Postoperatively the tongue was partially paralyzed, as was also the left vocal cord. The patient had great difficulty for a number of days in clearing the throat of saliva. The microscopic report was neurofibroma from the carotid sheath. Clinically, the tumor had most of the signs of a carotid body tumor though not of the usual pathologic variety which is often described as perithelioma. There was no thrill or bruit as is present in some cases.

The speaker had seen three other cases which he had diagnosed as tumors of the carotid body. The first case, many years ago, was explored but proved inoperable. It was malignant and proved fatal in about two and one-half years. The second case was operated on after he had had an operation elsewhere ten years before. The tumor recurred and at the reoperation in 1928 it was removed, although undoubtedly not quite completely, as it has recurred and is slowly growing. Removal could have been complete if one were willing to sacrifice the carotids which would probably have resulted fatally. Had the external carotid been sacrificed, it might have been possible to do a complete operation. The tumor is no doubt benign. At the original operation part of the seventh, ninth, tenth, and twelfth nerves were injured. The patient has a hemi-atrophy of the tongue, paralysis of the vocal cord and some anesthesia of the pharynx. If another operation were done the speaker would not hesitate to divide the external carotid but would not chance ligating the internal. His last case was a woman of advanced years who had been observed at intervals for a dozen years. The tumor presses the tonsil and pharyngeal wall inward, and is increasing little if at all. The mass feels cystic as palpated through the pharynx, much suggesting a peritonsillar abscess. An aspirating needle was once inserted and drew blood. There is a distinctly expansile character to the tumor.

DR. HOWARD LILIENTHAL (New York) said that, although not having studied the subject embryologically or from the standpoint of minute pathology, he had done so clinically, beginning with a case in 1906, and another three years later, and that he had been especially interested in an article by Callison and McEnty in 1913. Doctor Lilienthal's first case had had an enormous tumor of the neck that proved to be inoperable. However, he removed as much as possible and Doctor Elsberg tried later to remove more. The patient died of recurrent hemorrhage a week or so after operation. Had Doctor Lilienthal known the nature of the tumor he would not have attempted to extirpate it. In his second case, he was able to make a diagnosis, though it was not absolute until confirmed by operation. The patient, a woman—the tumor occurring much more frequently in women than in men—had had the tumor for 30 years before it began to enlarge. At operation, the carotid was exposed and the tumor found to be so intimately ad-

herent to the carotid that it was necessary to sacrifice it. It was resected, together with the tumor and the internal jugular vein, the vessels being used as a handle to aid the dissection of the tumor. A number of years afterward there was a recurrence and the patient died.

At that time, it was generally thought by surgeons that tumors of the carotid body very rarely metastasized but that they almost always recurred locally, and, in Doctor Lilienthal's opinion, the reason for recurrence in his case was because the vessels were not extirpated, which should be done in a case of this kind because it is malignant. He said that in any future case with a reasonably certain diagnosis he would expose the common carotid quite low down, put a thin rubber band, not too firmly, around it so it would not occlude the vessel, and leave it there. The rubber band, being elastic, would gradually compress the artery so that in a week or ten days it should be possible to go ahead safely with the second stage of the operation, with a minimum danger of a cerebral lesion. If, meanwhile, signs of cerebral disturbance should develop, the rubber band could be removed.

Dr. John Douglas (New York) called attention to the fact that many cases of carotid tumor go on for a number of years with the tumor small in size, then apparently it becomes malignant and increases rather rapidly. Therefore, it is an exceedingly difficult problem to determine what should be done in these cases where there is so much danger from operation; that is, both a high mortality and morbidity. At the time Doctor Douglas reported the only case in his experience (1909), Keen had collected some 27 cases which, in addition to five that Doctor Douglas found, made 32 cases, in which there was 25 per cent mortality with 20 per cent of those not succumbing to operation having a recurrence and dying from that recurrence. In two-thirds of the cases, all three of the carotids were tied, which was one cause of the mortality, but in the group there had also been injury to the pneumogastric nerve, the sympathetic nerves, the recurrent laryngeal, superior laryngeal, hypoglossal or facial. With such a result, Keen advocated not operating on these cases. Several years later, Bevan, collecting a series of cases, reiterated this conclusion, stating that the mortality and morbidity made operation prohibitive. However, if the patient is seen at a time when the tumor is still removable—in Doctor Douglas's case it was only 1.5 by 2.5 by 3.5 cm.—and could be peeled out carefully from the external and internal carotid at the bifurcation, operation is indicated. On the other hand, if the tumor is large, the common carotid artery must be ligated; this must be done in large tumors infiltrating the carotid and surrounding tissue, and a useful preparatory procedure is to obtain graduated pressure by means of a Halsted clamp, or by putting a piece of fascia around the vessel, or by pressure against the carotid tubercle. By such means, one may determine when it is safe to take out the tumor. But Doctor Douglas would not consider it safe to put a rubber band around a blood vessel, as suggested by Doctor Lilienthal.

Dr. Charles E. Farr (New York) recalled that he recently reported at a meeting of the New York Surgical Society two cases of carotid body tumor from the records of the New York Hospital. One was a personal case in a young woman who had had the tumor a number of years and who made an excellent operative recovery. The tumor was of a mildly malignant nature and did not recur during a fairly long period of observation.

The second case was operated upon by Dr. Richard Meagher, on the service of Doctor Heuer. This was a middle-aged woman with a very ex-

tensive malignant growth which could not be entirely enucleated. She recovered and under radiation has remained well so far as her neck is concerned. Doctor Meagher reports, however, that she has had an entirely independent neoplasm, a carcinoma of the sigmoid, which has been operated upon with success and she is now apparently well.

Doctor Farr then reported a third case which was considered to be a carotid body tumor but which on pathologic study is considered very doubtful. This was in a young Italian man, 32 years of age, who entered the New York Hospital July 18, 1935, and was discharged July 30, 1935. He was a printer by occupation. For three years he had had a slowly increasing growth at the angle of the left jaw, without symptoms. Since January, 1935, the growth had become much more rapid. He had had frequent colds and carious teeth but no sore throats.

Physical examination revealed nothing abnormal except a mass about 5 cm. in diameter, in the left neck below the angle of the jaw. This pulsated markedly and was definitely in the carotid notch. It could be moved laterally but not upward or downward. It was not expansile. Pulsation could be seen. The mass was free from the skin, was beneath the muscles and seemed to diminish slightly on pressure. The pupils were equal and reacted normally to light and in accommodation. The left optic nerve head appeared slightly hazy.

He was operated upon, after the subsidence of a mild febrile reaction, through a T shaped incision. A large tumor was found filling the carotid notch and extending into the depths of the neck. The dissection from the carotid vessels was quite difficult and somewhat bloody. Deep dissection was accomplished by blunt enucleation and was only moderately bloody. There was no pedicle.

Two days postoperative, a Horner's syndrome was noted and this has persisted since. The wound healed without complications. The patient's general health is excellent at present. Horner's syndrome is still present. The pathologic report by Doctor Foote is as follows: "The specimen consists of a pyriform tumor measuring 6 by 5.5 by 3.7 cm. and weighing 56 Gm. It is composed of several lobules of firm, yellowish tissue separated by more vascular areas. On section it seems to be made up of areas of whitish tissue which is extremely vascular and arranged in convoluted fashion. In the center there is a reddish area 2.5 by 4 cm. which may be necrotic or very vascular. Accompanying the specimen are two lymph nodes and surrounding tissue. One node measures about 1.5 cm. in diameter and is firm and yellowish. The other packet of lymph nodes measures 3.5 by 1.5 by 1 cm. and is quite similar in appearance to the foregoing. It is apparently composed of three or four lymph nodes, more or less grown together. Contrary to expectations, the sections from this tumor show nothing resembling carotid body. It is composed of rather cavernous, vascular channels embedded in a very dense fibrous matrix in which collagen predominates. The cellular elements of the fibrous tissue tend to be grouped in a somewhat palisaded form, as in the case of a neurinoma, but Masson stains show no nervous elements whatsoever and the tumor appears to be a hemangiofibroma. The accompanying lymph nodes are covered on one side with a capsule and present a fairly normal architecture. There is a slight degree of fibrosis and some increase in the number of endothelial cells, indicating a mild, chronic, inflammatory process. *Diagnosis.*—Angiofibroma. Mild, chronic lymphadenitis." Doctor Foote states that he could not absolutely exclude the possibility that this is a form of tumor of the carotid body.

A slide was submitted to Doctor Ewing, whose report is as follows: "In the case of R. F. I am inclined to think the tumor of the neck is a peculiar form of fibrosing neurinoma, arising in a nerve trunk. The palisade arrangement of the cells is extremely suggestive of this tumor type. In spite of the absence of nerve elements by Masson's stains, I am disposed to hold to the diagnosis just the same. It has nothing to do with the carotid body."

Doctor Peterson thought that surgeons were inclined to consider carotid gland tumors more malignant than is the pathologist. The histologic picture is suggestive of a benign condition, although it is known that a definite percentage of these cases are clinically and actively malignant in their behavior. Only two cases in the literature have developed distant metastases and it was questionable in these cases. Tumors of the carotid body recur locally, but do not tend to metastasize at a distance.

DIGESTIVE PHENOMENA IN THE PSYCHOPATHIC PATIENT*

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IN THEIR association with the surgery performed upon the patients from the Psychopathic Wards of the Philadelphia General Hospital, the authors were impressed several times with the great discrepancy found between the clinical findings before operation and the conditions found at the operation or on the autopsy table. The thought consequently occurred as to whether a patient with a mental disease resulting in aberrations could not conceivably have associated nerve cell lesions that resulted in fallacious or at least misleading visceral symptomatic phenomena causing erroneous diagnoses. An attempt is made by reference to the literature and by an analysis of 15 cases to direct attention to this question.

In a recent contribution, Frazier, Watts and Uhle have given an excellent review of the literature on the investigations upon the influence exerted by the cerebral cortex upon gastro-intestinal activity. They mention the works of Watts and Fulton, who by faradic stimulation of the premotor area in monkeys produced marked increase in the peristaltic activity of the cecum and lower part of the small intestine, with often "peristaltic rushes" in the colon. Frequently, ring-like bands of contraction of the small intestine developed during the stimulus. The persistence of such bands aided by the active peristalsis results in some instances in an intussusception, often multiple, which did not produce obstruction under the conditions of the experiment. These same writers, however, in the course of performing autopsies upon monkeys subjected to operations upon various parts of the brain and spinal cord, found intussusception with obstruction to be the cause of death in three otherwise healthy monkeys.

Morbid hunger in cases of brain injury is mentioned by them as being described by Paget, Spiller, *et al.*, and Bruhn is quoted as saying that this is not due to increased metabolism. Fulton is quoted as thinking it is secondary to the hurried peristalsis and Watts adds that this rapid rush and consequent imperfect absorption may account for the frequent emaciation existing.

The frequency with which psychopathic patients have morbid hunger and other abdominal phenomena that result in foreign body ingestion should be borne in mind. Every physician or surgeon is familiar with the fact that a correct, complete, and intelligent history is one of the most if not the most important factor in many of our diagnoses. The proper description of the

* Read before the Joint Meeting of The Philadelphia Academy of Surgery and The Boston Surgical Society, February 4, 1935.

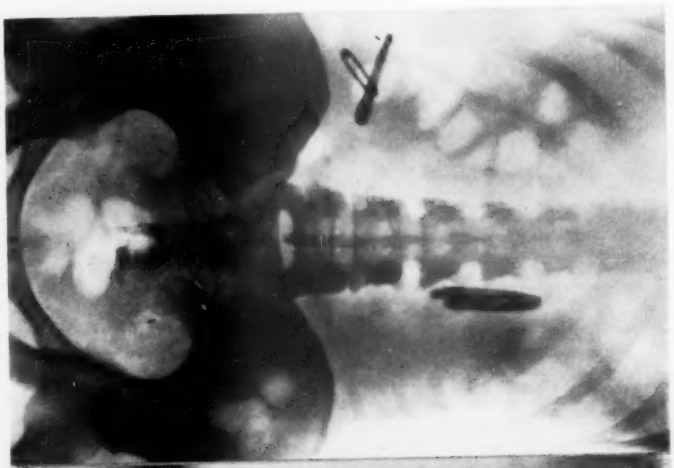

FIG. 1.—(Case I.) Closed safety pins in gastrointestinal tract.

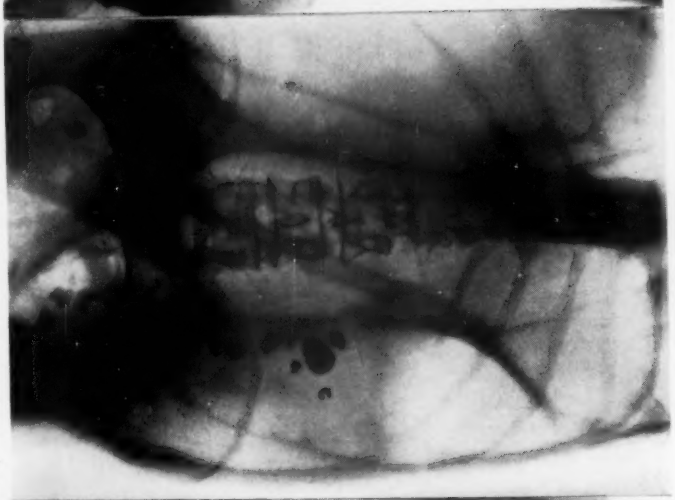

FIG. 2.—(Case II.) Paper, rags, hair, stones, Japanese beetles. Intestinal obstruction.

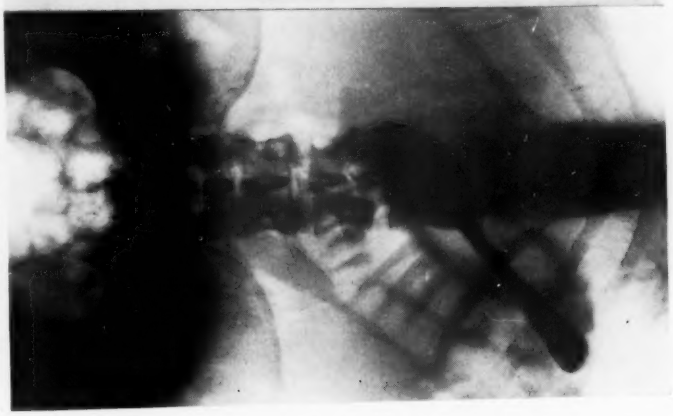

FIG. 3.—(Case III.) Dessert spoon in stomach. Dementia praecox.

pain or discomfort is very essential before significance can be attached to it. The psychopathic or insane patient cannot be relied upon for this help; hence the danger of erroneous diagnoses.

The same writers state that epigastric aura and other visceral sensations associated with convulsive seizures or occurring independently usually are not so called referred sensations but are the result of vigorous or abnormal gastro-intestinal movements. They also give evidence that urinary bladder representation exists in the cortex and hypothalmic region, stating that the abnormalities of bladder function, tone, and sensation in patients with brain tumors are probably the result of a disturbance of bladder representation in certain parts of the brain or tracts descending from them. Cushing some years ago called attention to the relation between the existence of peptic ulcer and certain brain lesions.

The mimicry of visceral disease, the result of the influence exerted by the cerebral cortex upon gastro-intestinal activity, may be illustrated by the following instances:

Case Reports

Case I.—Several years ago the senior writer saw a man in the Psychopathic Ward of the Philadelphia General Hospital who was thought to have a perforated peptic ulcer. The patient was a male, aged 38, of the slender, ulcer type so well described by Draper. The history was that about three hours previously he had been seized with a severe prostrating pain in the upper right quadrant of the abdomen, followed by nausea and vomiting. Physical examination revealed a T.P.R. of 98°—124—24. The patient lay on his back in a flexed or frozen position with knees slightly flexed. The abdominal wall had a boardlike rigidity, tender and resentful. Peristalsis was absent and the leukocyte count was 14,000. A diagnosis was made of perforation of a duodenal ulcer. At operation the peritoneal cavity was found normal with no evidence of peritonitis or perforation. The patient died 48 hours later and at autopsy no cause of death was discovered.

Case II.—The second in this same hospital, also a psychopathic case, was a man aged 52, admitted with the chief complaint of acute abdominal pain of five hours' duration. This pain began suddenly, was prostrating in character, and was located just to the left of the umbilicus. He had vomited. Examination showed a stout adult who lay absolutely immobile on his back. The abdomen was distended and revealed a right rectus scar of an operation four years previously for a "stomach ulcer" for which a "short circuit was done." There was boardlike abdominal rigidity and no peristalsis could be heard. The T.P.R. was 99°—120—22. Leukocyte count, 11,000. Tests for syphilis were negative. A diagnosis of perforation of a marginal jejunal ulcer was made. At operation the abdominal cavity was found to be normal except for the innocent adhesions incident to the well healed gastrojejunostomy. There was no evidence of a healed ulcer. This patient died within 72 hours and the autopsy revealed no cause for death.

Case III.—A third psychopathic case was a young Negress, 17 years of age, admitted to the hospital with abdominal distention equal to that of a pregnancy at term. The chief complaint was this distention and constipation although bowel movements could be obtained with laxatives. A thorough study of the case showed nothing of significance upon which to base a diagnosis. The spinal Wassermann was negative. The provisional diagnoses were tuberculous peritonitis or partial intestinal obstruction. Exploratory operation was undertaken. When the spinal anesthesia was given, the abdominal distention rapidly subsided, until in a short time it completely disappeared.

The exploration was carried out and a normal abdominal cavity disclosed. This patient recovered and at a later date was found to be in the habit of swallowing foreign bodies, chiefly small pieces of wood, several pieces of which were recovered in her bowel movements.

The above experiences led to the thought that possibly mental diseases might be responsible for gastro-intestinal phenomena similar to gastric crises or syndromes mimicking abdominal pathologic conditions, such as ulcer, intestinal obstruction, *etc.* If this were true, then, possibly there might here be a reason for those cases with real clear cut diagnoses of peptic ulcer which have shown no ulcer at operation. We have all seen and operated upon the "queer" patient with bizarre digestive symptoms suggestive of ulcer and yet not giving a typical picture, and operation has found no cause for, nor given relief to, the symptoms. Two brief histories will illustrate the points:

CASE IV.—A young man in his thirties was known to have paresis and the abdominal picture associated therewith. A gastro-intestinal roentgenologic examination reported a perforating prepyloric gastric ulcer. At operation a complete and exhaustive search revealed nothing. The patient's abdomen lent itself to an easy exploration in that the stomach and duodenum were very mobile. To be more certain, a gastrotomy was done and the lesser curvature evaginated through the opening. No ulcer was discovered.

CASE V.—Another patient presented himself with the history that he had had a gastrojejunostomy for a duodenal ulcer five years ago. He stated that the doctor told him that his case did not "fit" the pain picture, although an ulcer was found at operation. He was free from symptoms for one year and then different symptoms began in the nature of more or less constant pain in the upper left quadrant radiating to the back, but with no relation to food, yet was made worse by excitement or worry. Studies disclosed a normal functioning stoma. A definite diagnosis could not be made, after two or three complete and thorough hospitalizations. He was seen by a neurologist, who suggested a possible neurosis, and he was sent to a hospital for observation for several months. Later, the patient consented to an exploratory operation and two large perforated gastric ulcers were discovered.

The next group of patients, those who intentionally swallowed foreign bodies, are very interesting. There are many of these in the psychopathic wards, many more than are discovered. It is only when sickness justifies an examination that roentgenograms are taken of these patients and such foreign bodies discovered. It is reasonable to believe that many such cases giving no symptoms probably pass out bodies by the normal route. Why do they swallow pins, nails, spoons, hooks, glass, *etc.*? Is it because of abnormal hunger, or is it because of some peculiar and strange desire that a digestive disturbance causes? Many of the patients when asked why they swallowed such things will state because they had indigestion; others will deny having done so. Can these phenomena be abnormal visceral impulses with their source in a diseased brain?

Insane and psychopathic patients are prone to swallow foreign bodies because of no known reason, or from suicidal intent, or spite. Occasionally they are observed to do so, often they are not. When the latter is the case,

the attending physician is frequently misled in making a diagnosis, as the case is first apt to present itself to him as an acute abdomen. Often the patient is admitted to a surgical service with a diagnosis of intestinal obstruction, acute appendicitis or perforation of a hollow viscus. The objects swallowed may consist of any object that the patient takes a fancy to and which is capable of being ingested. Generally the objects are metallic or opaque to the roentgen ray, though two of our patients swallowed lead pencils and wooden tongue depressors.

Our experience with these patients has led us to the conclusions that a

FIG. 4.—(Case VIII.) One hundred nails in the gastro-intestinal tract.

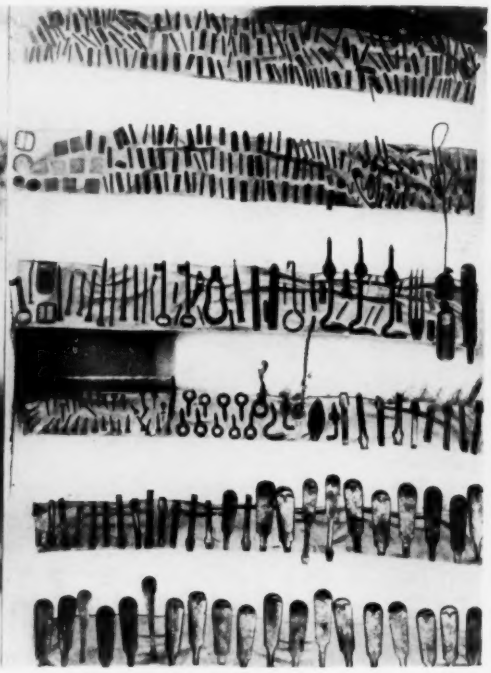

FIG. 5.—(Case IX.) Four hundred fifty-six foreign bodies removed from the stomach. Total weight, three and one-half pounds.

flat roentgenogram should be made of the abdomen in all feebleminded or insane patients who complain of abdominal distress which persists for more than several hours. Whether it is known that the patient has swallowed a foreign body or not, the diagnosis and location of the object rests upon roentgenologic examination.

The concomitant train of events which follow such depraved cravings may prove serious or not depending upon the clinical course of such patients. Apparently the gastro-intestinal tract is able to overcome many insults, whether of an alcoholic, metallic or medicinal nature. Surgical intervention is not always, but, rather, only occasionally necessary. When performed it should be judicious. Occasionally an acute surgical abdomen re-

sults from such abnormal ingestion. Largely in our experience, however, foreign bodies in the intestinal tract are well tolerated and seldom prove to present an immediate surgical problem. Frequently the objects are eliminated during the course of observation and conservative study. Indiscriminate surgery is not justifiable. As in so many conditions, the patient, rather than the roentgenogram, should be treated. Perforations of hollow viscera occur, certainly. The occasional occurrence of such catastrophes, however, is no warrant for general operations performed without adequate preoperative study, treatment, and preparation. This is especially true where there are multiple foreign bodies scattered throughout the intestinal tract and where multiple enterotomies serve only to increase the operative mortality.

The patient most often will not disclose the fact of having swallowed

FIG. 6.—(Case X.) Fifty-nine pieces of lead pencil removed from the stomach and one from a perforated cecum.

anything unusual. Sometimes they will volunteer the information. They frequently give indigestion as a reason for the habit; other times they have no reason. The character of the objects swallowed depends to some extent upon what is most easily obtained and may vary considerably, ranging from a cigar lighter to printers type. Some patients are selective in their diet, restricting themselves chiefly to spoon handles, or to safety pins, nails, screws, pencils, screweyes, *etc.* It has further been observed that a particular individual frequently develops a habit in that he will swallow all or most of his safety pins closed, whereas the next one's habit makes him prefer most of his pins opened or even straightened out. One patient's cecum was filled with Japanese beetles; another's rectum and sigmoid was packed solid with coffee grounds. These individuals often persist in their unusual appetites

after an operation and have been known to swallow mouth thermometers, wooden tongue depressors or safety pins removed from their dressings. Again they are selective in that in our experience they will rarely swallow a whole spoon, but usually break off the handle and swallow it, discarding the bowl. They do not swallow fork handles—probably because forks are not furnished them. In the hundreds of ingested articles only one fork was discovered.

Table I presents in condensed form the salient points in the histories of ten cases that are illustrative of the association between psychopathic conditions and abnormal gastro-intestinal activities producing fallacious deductions and many times unwarranted diagnoses.

TABLE I

Case	Age	Diagnosis	Digestive Symptoms	Objects	Treatment	Result
6	39	Psycho-neurosis	Indefinite	Safety pins, closed (Fig. 1)	Scope	Recovery
7	55	Puerperal psychosis	Vomiting, pain, ileus	Paper, rags, hair, stones (Fig. 2)	Oper.	Death
8	23	Dementia praecox	Pain in abdomen	Spoon in stomach (Fig. 3)	Oper.	Recovery
9	35	Mental defective	Pain, nausea, vomiting	Pins in stomach	No oper.	Recovery
10	35	Mutism, pervert	Colicky pains and vomiting	Safety pins and nail (?)	No oper.	Recovery
11	19	Psycho-neurosis	Abdominal pain and vomiting	Tongue depressor, swabs, thermometer	Oper.	Recovery
12	61	Manic depression	Belching, suicidal attempts	Vial in stomach	No oper.	Recovery
13	45	Undiagnosed	Ulcer symptoms for four years	100 (?) tenpenny nails (Fig. 4)	No oper.	Recovery
14	40	Dementia praecox	Indigestion	456 foreign bodies (Fig. 5)	Oper.	Recovery
15	25	Undetermined	Abdominal pain (appendicitis)	Lead pencils (Fig. 6)	Oper.	Recovery

In the entire series there are ten other cases who swallowed foreign bodies, none of whom had complained of any abdominal symptoms previous to operation. Some of these were discovered incidentally in the excreta and in others a rotentgenogram taken for other reasons revealed their existence.

We wish to take this opportunity to express our appreciation to the other members of the Staff of the Philadelphia General Hospital for their kindness in allowing us the privilege of reporting cases from their services.

CONCLUSIONS

(1) The inability of a psychopathic patient to clearly define his symptoms renders diagnosis more difficult.

(2) Mimicry of visceral symptomatology further increases the difficulty of a correct diagnosis.

(3) The human gastro-intestinal tract is shown capable of expeditiously caring for many most extraordinary, variable and numerous foreign bodies. Consequently too hasty surgery in the absence of symptoms is unjustifiable.

(4) It is still as dangerous as ever to attribute symptomatology to a suspected psychoneurosis.

LIVER STONES

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(*Continued from page* 336)

CLINICAL PICTURE, SYMPTOMS AND DIAGNOSIS.—The clinical picture of hepatolithiasis varies greatly. On the whole it resembles the clinical forms of cholelithiasis, ranging from the symptomless stone carriers to cases presenting the evidence of obstruction of the bile ducts, such as jaundice from stasis, liver insufficiency, cholangeitis, liver abscess and sepsis.

It is very difficult to find characteristic liver stone symptoms and differentiate them from those seen in cases of gallstone, because in the great majority of instances gallbladder, bile duct and liver stones coexist. Long duration of the condition, its obstinate resistance to all form of treatment and the advanced age of the patient when stones are found at operation or autopsy appear to predicate liver stones. Liver stones in younger people (such as in Fedorow's case of a boy 13 years of age who had suffered for three years), are characterized by their long duration and marked infection (possibly secondary).

Sex plays no part in its relative frequency. In cholelithiasis, the ratio of men to women is 1 to 456. In hepatolithiasis, the ratio is equal, 1 to 1; in fact, more men seem to be affected than women. In Japan and China, these figures vary from 1 to 1, to 5 to 9, in cholelithiasis. In 613 autopsies, 306 were women.

Notwithstanding the long duration and obstinacy of the disease, selective operations are few. Repeated operations, however, are more frequent than in usual cases of cholelithiasis. We find a large percentage of autopsy material showing nearly 30 per cent in this condition without having had any previous operation.

Peritonitis or perforation are scarcely ever found at operation or autopsy and only in the more severe cases do we find cholangeitis, liver abscess, marked liver insufficiency or sepsis. The percentage of complicated and aggravated cases is larger in this disease. We will later present the varieties of hepatolithiasis occurring in patients with concomitant pathology in the extrahepatic ducts and those without any such complication.

Reviewing the material at hand, the following figures on sex and age can be presented. In these statistics, the age was not known in four cases (Table II). In 28 males and 27 females, there were:

TABLE II

AGE RANGE OF FIFTY-ONE CASES OF LIVER STONE

13 years	— 1 case	
18 years	— 1 case	
20 to 30 years	— 5 cases	33%
31 to 40 years	—10 cases	
41 to 50 years	—17 cases	33%
51 to 60 years	— 7 cases	
61 to 70 years	— 5 cases	33%
71 to 83 years	— 5 cases	

Two-thirds of the cases were over 40 and one-third over 50 years of age. Collection of statistics as to the ratio of profession, occupation and mode of life was difficult due to incomplete histories, but we were able to collate the frequency of incidence of the process due to type of nourishment as stated by the Japanese and Chinese.

TABLE III

DURATION OF THE DISEASE IN THIRTY-EIGHT CASES

Under 1 year	—6 cases
From 1 to 3 years	—9 cases
From 4 to 6 years	—4 cases
From 7 to 10 years	—3 cases
From 10 to 15 years	—7 cases
From 15 to 20 years	—5 cases
From 20 to 30 years	—4 cases

Over 50 per cent had a long duration of the process and in only a small percentage of cases was the disease of recent origin (Table III). In a number of instances, the history stated only that the disease had been of long duration, without specifying the exact time.

The symptoms complained of upon admission are the same as those of cholelithiasis. The most frequent are pain, jaundice, elevated temperature and tumor, or enlargement, in the right upper abdominal quadrant; and, more rarely, dyspeptic disturbance and inanition.

Pain.—Occurs most frequently in the form of attacks of rapid onset and of more or less long duration. Treatment relieves the pain only in rare instances. As the process develops, the frequency and continuance of attacks increase in number and intensity. After a long interval, the characteristic clinical picture of a severe cholangeitis, liver abscess or sepsis, may suddenly present itself. In 10 per cent of the cases a dull pain remains after an attack.

In exceptional cases there was no pain at all and a clinical picture of the condition was masked by other symptoms and hepatolithiasis was excluded. Cases are known where the pain radiated to shoulder and scapula. In some cases, the pain was concentrated in the epigastrium for a long period of time, being intense and severe enough to drive the patient to operation.

Temperature.—In the majority of cases, and with very few exceptions, the temperature is elevated. The usual temperature, as seen in cholelithiasis, is present, but changes in relative proportion to the pathologico-anatomic change in the liver, such as purulent cholangeitis, liver or other abscesses, and pleurisy. Not less than 25 per cent of the cases were accompanied by chills.

In some rare cases, the temperature is not elevated at all (Kenelm, Digby, Eickhoff and others) or is subnormal. In some instances, the temperature, after being normal over a period of months or years, ran a typically septic course, which predicated a complication or a progression of the disease.

Jaundice.—The majority of cases are accompanied by jaundice. If it is absent upon admission, the past history in many instances will reveal its presence sometime during the patient's illness. It is most frequently an obstructive jaundice. The autopsy confirms the closure of the common duct. After proper drainage of the ducts, the jaundice usually became less or disappeared entirely. In some cases, however, it did not disappear at all after draining the ducts. The autopsy in these cases divulged closure of the intrahepatic ducts and liver insufficiency. Pruritis, hemorrhages, changes in the urine content and stool, following jaundice, are present in these cases as they are in cholelithiasis.

Gastric Disturbances.—Are observed in the majority of cases. This is due to changes in the secretory and motor function of the gastro-enteric canal. Indigestion or dyspeptic symptoms, anorexia, vomiting during the attacks or sometimes at their termination, definitely connected with time of eating, achlorhydia or hyperchlorhydia, constipation, sometimes diarrhea, are the symptoms which typify the disturbance in the gastro-intestinal canal. Sometimes inanition and anorexia are the early symptoms of a severe liver pathology (case of Eickhoff). Intestinal or pyloric stenosis or intestinal occlusion occurring as clinical symptom complex predicate the presence of adhesions to important adjacent organs (stomach, duodenum, *etc.*).

Acholic Stool.—Is frequently met with and indicates delayed or obstructed flow of bile. Degree of closure of the biliary ducts, however, will not always run parallel with discoloration of stool. The stool may not be entirely discolored and yet the ducts can be entirely filled with a bile colored, compact mass, or tensely filled with stones; or conversely, the stool may be discolored and the ducts may be apparently and relatively patent.

The passage of stones in the stool was observed only in isolated cases, which in reality would have been seen more often if the patients had examined their stools more frequently.

Liver.—The liver is either found enlarged upon admission of the patient; enlargement is stated in the patient's history; or it is found at operation or autopsy. Sometimes, prior to operation, notwithstanding its diseased condition (jaundice) the result of liver function tests will be found normal. In a number of cases (Beer) the liver was accepted as normal. However,

it could only have been judged by external findings, because the presence of a severe cholangeitis would hardly predicate a normal liver.

As a rule the liver is uniformly enlarged, yet in a number of cases, this enlargement was confined only to one lobe or only a part of the liver which, however, reached large proportions. This liver enlargement, or tumor, sometimes forms the essential and only sign when the patient is admitted.

The Gallbladder.—The gallbladder is sometimes enlarged to the size of a fist, or larger, and may reach to the umbilicus. In at least 20 per cent of the cases it was not palpable. Inflammatory reaction in the gallbladder or in its immediate surrounding tissue is accompanied by tenderness and sometimes pain in the gallbladder region.

The Spleen.—The spleen is rarely mentioned in the clinical histories. As soon as septic symptoms appear, the spleen becomes very much enlarged.

The other organs, such as circulatory system, lungs, kidneys and nervous system, not infrequently are involved in the general pathologic process, the symptoms manifested being collapse, shock, spasm, biliary or purulent pleurisy, edema of the lungs and severe forms of nephrosis, nephritis and anuria.

The abdominal wall is sometimes tense, tender and painful. The pain and tenderness, besides other concomitant symptoms, are characteristic of the acuteness of the condition, of liver abscess or the presence of a perforation.

It is apparent that all the above mentioned symptoms do not typify anything characteristic of hepatolithiasis. The same symptoms hold for cholelithiasis. Search for past infection from which the patient has recovered does not accomplish anything. A definite relation or connection of a definite infection from which the patient has recovered in the past, with hepatolithiasis, can never be established. Frequently typhus (abdominalis recurrens), rarely malaria and syphilis, will be met with—yet not in any higher percentage of cases than in other diseases, such as we find in the history of renal sclerosis in kidney disease.

With this symptom complex, hepatolithiasis as an entity is rather difficult to diagnose. Roentgenograms may be useful, but, as the case histories show, they are not often taken. In the case of Hawkes, after a cholecystectomy, attacks of pain returning, the films showed the shadow of a stone above the bile tracts. Operation confirmed the roentgenologic interpretations.

Heiser, in 1914, describes two cases where the roentgenogram showed scattered stones in the liver parenchyma besides those in the gallbladder. Matrossow reports a case of recurring pain and biliary fistula a number of months following the opening of a liver abscess which contained a stone. Probing the fistula disclosed another stone in the left lobe of the liver. A roentgenogram also disclosed another stone in the right twelfth intercostal space, next to the eleventh and twelfth vertebrae which was removed by operation. These facts establish the necessity of roentgenologic examination in suspicious and vague cases, especially when there is a recurrence

of pain or reappearance of jaundice postoperatively. No case was correctly diagnosed except those which were examined roentgenologically before operation.

If there was no autopsy after operation a correct clinical diagnosis was not accepted. In some cases it was noted that the operation revealed only the liver tensely filled with stones, the removal of which was impossible, or the liver was nodulated, the nodules containing stones. Frequently, however, the operation failed to establish a correct diagnosis.

In the majority of cases, the diagnosis of complicated cholecystitis, obstruction of the common duct or cholangeitis is made. Another group of patients were admitted with an encapsulated liver abscess and enlargement of the liver. This enlargement was almost always an abscess containing stones, or stones were expelled later. Sometimes this enlargement was diagnosed as an echinococcus cyst, or cancer of the liver.

Pancreatitis should be considered in the differential diagnosis in addition to abscess, echinococcus cyst and other various forms of diseases of the bile ducts and gallbladder. The acute and severe course of hepatolithiasis sometimes simulates acute pancreatitis and has been diagnosed as such. More frequently, however, ductal obstruction with atypical symptoms of cholelithiasis presumed the diagnosis of a chronic, indurative pancreatitis which the operation at times confirmed. Pancreatitis has also been diagnosed as the primary disease instead of the complication, which it really is, and the operation was confined to an exploratory laparotomy without any successful result, the subsequent autopsy establishing the true diagnosis. The mistakes in diagnosis are embraced in the above mentioned borderline cases of pathology of the process.

The Japanese offer interesting data concerning liver stones, due to its more frequent occurrence there than in any other country. The Pathologico-Anatomic Institute at Kiuchu (south) cites six cases, nearly all coming to autopsy, coexisting with lesions in the extrahepatic bile ducts. Of these, nearly all were 20 to 40 years of age. The clinical diagnosis of cholecystitis, cholangeitis, liver abscess and cholemia came closest to the true diagnosis.

In the Pathologic Institute statistics, at Tokyo (north), the 13 cases of hepatolithiasis cited coexisted with 50 per cent lesions of the extrahepatic ducts. The patients were between 60 and 81 years of age. This group came to autopsy with the diagnosis, before death, of apoplexy, shock and mania, *etc.*

It appears that in these cases the existence of liver stones was not even considered, which can be accounted for by the kidney and heart disease from which a number of these patients died. It is difficult to exclude the hepato- and cholelithiasis as one of the etiologic factors responsible for the damage to the heart, kidneys, blood vessels and nervous system. A connection between these processes, however, is unquestionable.

These data allow us to establish a schematic set up of two groups in the clinical course of the process. In the first group, we placed cases with

a relatively rapidly developing liver insufficiency in people who are not old, or a virulently active infection with exitus from gallstone disease during middle age. In the second group, in most cases, the liver insufficiency does not appear before 60 to 80 years of age and the infection, if it does occur, is not severe and does not assume a virulent form. In consequence the patients die of damage to other organs. The pathologic changes of the diseased liver, the infection of the bile passages and the toxemia, although probably playing an important rôle, were not considered immediate causes of death. Cholemic bleeding was not met with in these cases.

Diametrically opposed in their course and clinical picture, we find patients in our collected cases, as for instance Case III or in Fedorow's cases of the 13 and 23 year old patients, Case V, where very marked liver changes and a stormy course presented an entirely different syndrome when compared with that noted in the 65 year old patient reported by Beer where the first symptoms of gallstone attacks occurred only four weeks prior to consultation or that in a 79 year old patient where gallstone attacks were absent and the patient rapidly died from sepsis, in whom the autopsy showed the presence of a great number of stones in the bile ducts and in the liver with definite and marked changes in the latter.

Treatment and Causes of Death.—Out of 57 cases, 41 were operated upon.

Table IV

TYPE OF OPERATION PERFORMED IN FORTY-ONE CASES

	Cases
1. Inspection or aspiration of gallbladder	2
2. Gallbladder fistula	10
3. Cholecystectomy	18
4. Choledochotomy	18
5. Hepaticotomy	3
6. Cholecystogastrostomy	1
7. Cholecystoduodenostomy	1
8. Hepaticoduodenostomy	0
9. Opening liver abscesses	5
10. Removal of liver stones	7
11. Opening dilated cystic duct stump and removing stones	1
12. Section of scar and fistula	3
13. Gastro-enterostomy	1
14. Fistula of the cecum	1
15. Opening lung abscess	1
16. Incision of subdiaphragmatic abscess	1

This table shows that the most frequently performed operations are cholecystectomy (18 cases); choledochotomy and hepaticotomy (21 cases), and twice less frequent is a cholecystostomy with establishment of a gallbladder fistula (10 cases). In 12 cases, a liver abscess with stones was opened, or a portion of lithiac liver tissue was resected, including its stones. In 32 cases, gastro-intestinal anastomosis with the bile ducts was done. Other

procedures, such as opening up the stump of the cystic duct, or resection of scars, opening and resection of fistulae were resorted to at secondary, or repeated operations. Gastro-enterostomy; establishing a fistula at the cecum and rib resection, were operations of necessity indicated by complications. In two cases of Miyake, the hepatolithiasis was not recognized at all at operation, the surgeon confining himself only to inspection and incision of the gallbladder.

Two cases were reoperated on and in the one inspection of the abdominal cavity revealed a hernia which had developed from the first operation for the removal of stones. There were no visible changes in the region of the bile ducts (Büdinger). In the second case (Körte), a cholecystectomy with drainage of the cystic duct had to be done six weeks after a cholecystostomy with fistula had been performed, and one-half year later a choledochotomy with drainage was done on this same patient.

After seven cholecystectomies, two of which were accompanied by choledochotomy, three operations of entero-anastomosis had to be done, one year later in the case of Rufanov and one and one-half years and ten years later in the case of Terebinskij. Twice, after two and after six years, Hawkes and Kadjan opened the liver to remove stones, and in one case a second choledochotomy had to be done after four months for the removal of a newly appearing stone. In one case stones were removed through the unhealed, biliary fistula (Kahiske). In another case, gastro-enterostomy for pyloric stenosis was performed; three years after the first operation and eight years later a fistula was made in the cecum because of adhesions threatening intestinal obstruction.

In the case of Jukelson, an abscess in the epigastrium was incised first and this had to be followed by drainage of the subdiaphragmatic space and finally, by cholecystectomy and choledochotomy.

It is striking how the number of relaparotomies is definitely more frequent in hepatolithiasis than in cholelithiasis. This is partly explained by the severity of the liver stone pathology and also by not recognizing the existence of liver stones at the time of the operation on the gallbladder and particularly, in the latter instance, by the short period of drainage, precluding a good end-result.

The most important question of the expediency of the operative procedure adopted and the errors made while operating, can be answered by a review of all the material subjected to surgery. This may be divided into three groups:

(1) Cases which were cured.....15
(2) Cases which died.....25
(3) Cases which came to autopsy without any operation.....15

The easiest cases to cure were in the first group. Late results are not reported because probably there had not been a complete cure. First, all the patients were relatively young—two-thirds were not over 35, and only

one patient (Barth)[4] was 54 years old. In this case, the fistula, after a choledochotomy, was still draining after 13 months. Flushing the fistula and bile ducts caused many stones to be expelled, after which the fistulous tract closed rapidly. Second, the duration of illness was shorter than in the second group. In 40 per cent, the condition did not continue over three years and in 25 per cent less than one year. Third, the clinical picture was usually different than in the second group. In 80 per cent of the cases there was a circumscribed process. In five cases the operation consisted of abscess incision, and in three cases stones were removed, with a resection of a portion of the liver parenchyma. In one case there was a congenital absence of the gallbladder and by choledochotomy and draining the common duct the patient was saved. Three cases were so called "fresh" cases, presenting, so to speak, the first step in the formation of solid stones (Büdinger[10]) which the author also emphasized in a third, analogous case in which, however, the general condition was too far advanced and the patient died.

The twelfth case (Kenelm[11]) was a 34 year-old patient whose first attack dated back nine months. Drainage of the gallbladder ducts and removal of stones definitely settled the operative result. The presence of white bile, enlargement of the liver, *etc.*, is a definite confirmation that the operation is performed at the right time. Finally, in the thirteenth and fourteenth cases (Kadjan and Terebinskij[54, 55]) there was a long interval between the first and second operations, during which time the patient felt well (ten and six years). In Terebinskij's case, the operation showed a kinking of the hepatic duct containing an intrahepatic arborized stone, involving the hepatic as well as the common duct. It is quite clear that the stones existed before the first operation. Their slow growth can be explained by displacement of the bile duct which occurred by the formation of scar tissue in the surrounding tissue after the first operation.

In the very interesting case of Kadjan, after the first radical operation of cholecystectomy and choledochotomy, there ensued a period of six years of complete health. At the second operation, performed because of colic, jaundice and acholic stools, another choledochotomy and removal of stones from the common, as well as the hepatic duct, was done. The surgeon was able to palpate a deeply lying stone which he was able to remove after opening the liver with a Paquelin cautery. This stone could easily have been overlooked and the results of the operation would have been different.

All cases of cure as related to the time of operation were of short duration.

Surgery of the bile ducts only began to develop 40 years ago and rapidly advanced during the first and second decades of the twentieth century, to the status of development it enjoys today. During this time, countless thousands of gallbladder operations were done. Experience thus gained, as we can perceive in the second and third groups (Mermann[36]) expressed itself in the indications for the operation and in the operative technic itself.

It will be noticed that these groups show a very large percentage of patients with liver stones, without, however, any pathology of the gallbladder or bile ducts. This brings about a greater difference as a result of treatment.

In the majority of cases, simple surgical procedure, in the first group, was sufficient to bring about a good result. This was due to the relative youth of the patient, the short duration of the illness, the limited extent of the process and the absence of general damage to and insufficiency of, liver parenchyma and tissue, as well as other parenchymatous organs (kidneys); and finally, the absence of any inflammatory process in the bile ducts and capillaries (cholangeitis and cholangoitis). This we were able to observe in the next group. We were unable to ascertain the length of time of cure with definite certainty in a number of cases. Observation was not made over a long period of time in some cases. Recurrent, or rather, progressive development of the pathology, without doubt, went on unchecked.

Twenty-five cases, with autopsy shortly after the operation, belong to the second group. These were protracted cases, with severe clinical and pathologico-anatomic changes in the liver and other organs. The patients in this group, as compared with the first, were very much older. Although we find only one case at 50 years in the first group, we find only three patients in 25 cases under 50.

One case presented the picture of a fully developed, intense form of frank liver insufficiency with general kidney symptoms and at operation all the stones could not be removed. Another patient had ten attacks during the course of two years. Some of these attacks began with chills and lasted two months. Operation showed an intact gallbladder and extensive changes in the liver, as well as the pancreas, the insufficiency of the latter causing the patient's death, 18 days later.

In the third case, that of a 13 year old boy, the attack began at three years of age. The findings at operation were, a thickened mass, tensely filling the intrahepatic and extrahepatic bile ducts, with a mixed infection of *B. coli*, *B. perfringens* and diplococci, complicated by a purulent diplococcus pleurisy. All the other patients, however, were between 50 and 60 years of age.

The duration of the disease in this group was decidedly longer than in the first. We find patients with 15, 25, to 30 years' duration of the disease suffering from repeated attacks of severe obstructive jaundice, infection in the bile ducts and enlargement of the liver. Individual cases where the duration of the disease did not exceed two to four years accompanied, however, with complications in the liver (cholangeitis, cholemia) as well as those of other organs, were seen.

The clinical picture is much more severe than in the first group. Due to prolonged duration of the disease, it will definitely manifest itself before operation. These patients were admitted in a septic condition, with cholemic changes of the kidney, *etc.*, and at times it was found during the operation that all the stones could not be removed.

We found 80 per cent of the cases in the first group with a circumscribed process without any involvement of the extrahepatic ducts, while in 90 per cent of the second group we found coexisting gallbladder and liver stones. In only two cases was the process entirely confined to the liver. In both these cases, the operation was only exploratory, the autopsy revealing a purulent cholangeitis and liver abscess.

A certain number of operations in this group really belong to the early period of gallbladder surgery when the indications for operation were approached with greater caution and choledochotomy was attempted only in occasional cases. It is easily understood why the operative procedure, as for instance in the two step operation, in the presence of angiocholitis and stones in the ducts, sometimes proved insufficient. Such errors, however, were few and can be observed in only three patients.

The causes of death in this group were as follows: In two cases, death did not follow immediately after the operation. One was an instance of obstruction of the bowel from adhesions, in which case a fistula was established. The other was a case of lung abscess in an old, cachectic patient, in whom a rib was resected. Probably the lung abscess, as well as the intestinal adhesions, were etiologically connected with the original disease. In the other 23 cases, the following causes of death existed: (1) liver insufficiency, 16 cases; (2) purulent process (angiocholitis and liver abscess, 7 cases).

Death followed very shortly after the operation which is easily understood when one analyzes the essential causes of death and their result, namely—liver insufficiency, cholemia (Kenelm[11]); gastric hemorrhage (Oehler[40]); convulsions (Büdinger[10]); soporific condition with semicoma (Harper); postoperative "liver coma" with absence of bile drainage; appearance of white bile; ascites (Kehr and Kenelm), and necrosis (Rufanov).

In all the cases, the bile ducts, up to their most minute branches and arborizations, were completely filled with stones in a chain or tandem-like, compact, clay colored mass. In a number of cases not all the stones could be removed at the operation, so that it was really only exploratory (Haberer,[21] Rufanov[46, 47, 48]). In cases coexisting with cholangeitis, although the clinical picture of liver insufficiency was present, the infection was overwhelming.

Besides liver changes, cases of coexisting kidney degeneration, anuria (Rufanov and Haberer), perforation of the gallbladder and circumscribed purulent peritonitis, leading to gastric, omental and intestinal adhesions; sometimes a septic condition (Rufanov), embolus and infarct in various organs (Kaliske[26]), were seen.

We place cases not operated upon, but autopsied, in the third group. They were 15 in number. In two, the stones were found only coincidentally (Hesse[18] and Beer[5]). In one, the history was not known. The other cases were mostly all 60 to 80 years old and had undergone a prolonged internal and mineral spring treatment. They were admitted with signs of severe cholangeitis, liver or subdiaphragmatic abscess, ulceration of the gallbladder or bile ducts following a long continued lithiasis and infection, as well as

cholemia, hemorrhage, sepsis or collapse. We were dealing with neglected and prolonged cases of cholelithiasis with duct obstruction which had not been operated upon at the proper time. Some of these patients presented the clinical picture of a rapidly (four to five weeks) developing, purulent cholangeitis following a long continued, sometimes symptomless lithiac disease which, proved by autopsy, could only have existed for years.

It is unquestionable that in the beginning of today's modern surgery, the absence of definite physiologic reasoning for diagnosis, indication for operation, prognosis, and the undeveloped state of surgery, as well as the long continued confidence in all other therapeutic measures was the reason the cases in this group were not operated upon earlier.

Forty patients out of the 55 died, a mortality of 75 per cent. One notices that there is a marked difference in the course of the condition when dealing with extrahepatic duct stones with coexisting liver stones, or in cases of liver stones existing alone. First, in 26 cases with coexisting liver and gallbladder stones and stones in the large bile ducts, we find five cured. Second, in 18 cases of stones in the liver, coexisting with stones either in the bile ducts or only in the gallbladder, we find three cured. In one of these cases the gallbladder was absent. Third, in 11 cases of liver stones existing alone, seven cases were cured. One was not operated upon at all, and two were not even treated.

If we compare the third group, we find that the patients with unfavorable operative result (second group) as well as those not operated upon who died, form nearly an equal quality group which is sharply defined from those of the first group who have recovered from their operation.

Case Reports

Case I.—(Rufanov). Thirty-five year old female, admitted December 25, 1922, complaining of constant pain in half of the right upper abdominal quadrant, increased after eating. Six months previously suffered an attack of diarrhea, epigastric pain, with vomitus of bile, chills and feeling of chilliness with a temperature rise to 38.0° C. which dropped to normal in ten days, leaving her generally weak. The pain increased steadily, added to which she suffered from pyrosis and eructations. Upon admission, a movable, hard mass about the size of a fist was palpable in the right hypochondrium. There was a gastric subacidity.

Operation.—January 30, 1923. The liver was irregular in shape, the right lobe reaching into the pelvis, the left lobe presented an unusual incisure and an accessory lobe, 3 x 3 cm. in size which was suspended from its under surface. To the left and 1 cm. above the edge of the liver there was a white, scar-like spot, 2.5 x 2 cm. in size, which, upon incision and resection, proved to be a thin-walled cavity containing stones. A second cavity filled with stones was palpated on the under surface of the liver. Opening this cavity showed that it extended 6 or 7 cm. perpendicularly from the free edge of the liver into the liver tissue itself, while the left branch showed cavities which also contained stones. Resection of liver parenchyma, 6 x 10 cm. in size, and including the cavity containing stones, was done. To the right, and also in the remaining portion of the liver, no changes were found. The denuded surface was sutured.

During the postoperative period there was long continued pain and vomiting. Pathology of the liver tissue showed scar tissue changes, the liver containing many

stones. Microscopically, the dilated bile tracts contained bile pigment, the ducts surrounded by proliferated connective tissue. The stones were dark brown in color, of polyhedral shape and pulverized easily. Their chemical content (Prof. W. S. Gulewic) consisted of calcium combined bile pigment (cholesterin, bilirubin) and magnesium salts (Fig. 1).

CASE II.—(Rufanov). Male, 40 years old, admitted March 4, 1929, with pain under the right costal margin, radiating to the right scapula. History of syphilis having been contracted 15 years prior and a recurrence one year previously. The pain beneath the rib margin had begun suddenly 12 years previously, with a temperature of 40.0° C. which continued for three or four days. Similar attacks always recurred after doing heavy work, sometimes coming on twice daily. At times he was free from these seizures for three to four months. About one year before admission, had a sudden and especially severe attack with coma and a temperature of over 40.0° C., accompanied by severe pain, radiating to the right scapula. This attack continued for three weeks. His temperature fell, followed by jaundice which remained for 15 days. The patient was confined to bed for four months. After this the attacks recurred following any heavy work or severe physical labor. Jaundice, however, did not recur.

Examination.—Pulse, 72; accentuated heart sounds. Blood examination: Hemoglobin, 85; erythrocytes, 4,300,000; leukocytes, 7,000; coagulating time, two and one-half to three minutes; blood clot, 7 min. Urine examination: urates and isolated leukocytes. The liver was located two fingerbreadths below the right costal arch. The gallbladder was tender on palpation. The roentgenogram showed the outline of the gallbladder, definitely and continuously located on the level of the fourth lumbar vertebra. Gastric secretion showed a total acidity of 50 and free acid 30. Gallbladder reflex not present.

Operation disclosed an atrophic gallbladder, adherent to the pylorus and pyloric end of the stomach. While separating the adhesions from the liver, the gallbladder was accidentally opened and three stones, 1 cm. in diameter, were removed from it. Many stones were felt in the common duct and were removed in great numbers with a spoon. They not only filled the common duct, but also the right and left hepatic ducts. The common duct was drained, plus tampon drainage. There was a copious amount of bile drainage during the postoperative period. Enemata showed normal colored stools. General condition of patient satisfastory. The right lung showed an inflammatory process. The eighth day after operation the patient died.

Autopsy showed marked dilatation (about 4 cm.) of the common duct, with roughened and injected mucosa containing small, soft gallstones and mucus. The hepatic duct also was dilated. The liver was of usual size, flaccid and when cut showed evidence of isolated, red, healed, regeneration foci. The lumen of the large as well as the small bile ducts contained stones throughout, which upon section showed a light yellowish color. The pancreas was not especially altered. There was jaundice, a nephrosis, bilateral pneumonia and hyperplasia of the spleen.

CASE III.—(Rufanov). A 60 year old tailor, admitted September 14, 1929, with symptoms of epigastric pain, constipation and general jaundice. Ten years before, he had had typhus (spotted) fever of the abdominal type. Four years prior he had had malaria and measles. Two years before he had had intense epigastric pain, with nausea, vomiting and temperature of 38.0° C., the attack lasting four to five hours. Operated upon in January, 1928, for the first time, at Charkow. A cholecystectomy was done, the gallbladder containing stones. The patient was discharged in four weeks, feeling well. After nine months the same type of attack returned, accompanied by clay colored stools and general jaundice. Duodenal intubation resulted in a small degree of improvement. Treatment at a health resort afforded no relief. Lost 29 Kg. in weight.

Condition upon Admission.—Icteric sclera, acholic stool, eructation, nausea and vomiting. Dull heart sounds—rough breathing. Hemoglobin, 75; erythrocytes, 3,800,000; leukocytes, 7,400; blood coagulation time, two minutes and 20 seconds to three minutes;

blood clot, 8 min. Urine: urates and occasional leukocytes. Lower edge of liver two fingerbreadths below edge of rib curvature and the liver was tender on palpation. Total gastric acidity 94. Free hydrochloric acid, 66. *Direct* positive bilirubin reaction; diastase in urine; after eating mild marjoram—64.

Second Operation.—Anesthesia, morphine-chloroform-ether. Mobilization of duodenum. Opening common duct close to the duodenum from which flowed golden bile accompanied by a number of stones. Probing the duct upward and downward showed it to be unobstructed. A drain could not be inserted, however. Anastomosis between the common duct and the duodenum was done. Tampon drainage was instituted.

During postoperative period, intestinal paresis with singultus lasting a number of days occurred. There was a very copious bile drainage.

A third operation was performed in which a drain was placed between the duodenum and the common duct. Sutures were applied over the drain. This was done on the fifth day after the second operation, because of separation of the edges of the choledochoduodenal anastomosis. Severe singultus continued, the patient losing in weight and vitality with only occasional lessening of jaundice. The patient died 17 days after the first operation.

Autopsy.—Ulcer of the lesser curvature of the stomach, the size of a 20 kopeck piece. The edge of the ulcer was undermined and had a small bloodvessel coursing across its floor. Scar at the common duct. The drain lay next to the hepatic duct and entered the ampulla of Vater, passing into the duodenum. The liver was of usual size, flaccid and spotted here and there with bright yellowish colored, fibrous layered necrotic areas.

Large, as well as small intrahepatic ducts were markedly dilated containing an accumulation of small, soft, dark-brown stones. There was jaundice, kidney and biliary cirrhosis. The duodenal fistula at the site of the separated anastomosis presented incisura and indentations directed toward the ileocecal region. The splenic pulp, as well as the portal nodes, were hyperplastic. Dilatation and degeneration of the heart was present. There was an emphysema of the lungs and fenestrated aortic valves.

Case IV.—(Rufanov). Woman, aged 52. Admitted November 21, 1925, with signs of a lung abscess on the right side. Since the age of 35, she had had periodical, severe attacks of pain beneath the right curvature of the ribs, with temperature rise and vomiting. Had contracted syphilis at 35. Had had six healthy children. For one and one-half months, the lung manifestations consisted of: chills, temperature of 40° C. and foul-smelling expectoration. The spleen was enlarged, the urine contained kidney epithelium, leukocytes, erythrocytes and cylindroid casts. Hemoglobin, 65 per cent; erythrocytes, 3,900,000; leukocytes, 15,400. The sputum showed elastic fibers, streptococci and diplococci. There was positive dulness over the lower lobe of the right lung.

Operation.—Resection of the seventh, eighth, ninth and tenth ribs, followed by opening of a lung abscess. Wound tamponed. Patient extremely weak. No drop in temperature or improvement. Patient died 17 days postoperative.

Autopsy.—Septicemia. Abscess of right lung. Degeneration of heart and liver. The common bile duct was dilated and obstructed by a stone. All the bile ducts were completely filled with a granular, crumbly, brittle mass of formed gallstones.

Case V.—(Fedorow). February, 1926. A 23 year old female, ill two years. First attack lasting one and one-half weeks, characteristic of a liver colic with radiation to right scapula and accompanied by jaundice. Several months later she had a second attack, lasting two weeks. Since this time she has had attacks nearly every month. In August, 1927, she had her tenth very severe attack with chills, rise in temperature and jaundice, lasting two months. After two months there was a recurrence of the jaundice. The enlarged liver and gallbladder could be palpated. Phrenic symptom not positive.

Operation.—January 18, 1928. Incision according to Kehr. A somewhat dilated gallbladder with adhesions of the omentum to the under surface of the liver was found. Adhesions freed, no stones in the gallbladder. Hepaticoduodenal ligament was edematous

and the pancreas was enlarged. Cholecystogastrostomy was done. Postoperative history showed no improvement. Death.

Autopsy.—Enlarged pancreas. No stones in the gallbladder or hepatic duct, yet the liver itself contained an extraordinarily large number of stones in its intrahepatic ducts.

CONCLUSIONS

Contemplating the operative result, as well as the cause of death, we find that early operation performed during middle age or youth, on the extrahepatic ducts, will offer the best end-result for a positive cure, and, conversely, neglected and prolonged cases in advanced age with protracted illness, with intercurrent or secondary pathology of other organs, offer the greatest likelihood of failure. The percentage of cures can be high only if the process is circumscribed in the liver or if there are no changes in the extrahepatic ducts.

The treatment of solitary and multiple liver abscess, although analogous, is diversely different in operative result. In the first instance, the result of incision of the abscess and good drainage is definite and certain. In the second, however, even drainage is most often found to have been done too late.

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TRUE PROLIFERATING CYSTIC LYMPHANGIOMA OF THE MESENTERY

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CYSTS of the mesentery are undoubtedly among the rarest tumors encountered in the field of general surgery. In most text-books, the condition is not even mentioned; or, if mentioned, it is dismissed with a few brief words. Collins and Berdez[1] report that not a single case of chylous cyst was found in 15,000 necropsies at the University of Minnesota, and that in 200,000 cases at St. Mary's and St. Luke's Hospitals in Duluth, only two cases of chylous cysts were found. Alesen[2] was unable to find any cases of mesenteric cyst at the Los Angeles General Hospital during the years 1912 to 1929. Writers disagree on the number of cases of these cysts recorded in the literature, usually stating the number to be between 200 and 400. From a careful search of the literature, I was able to find approximately 500 cases of mesenteric cysts, while true proliferating cystic lymphangiomas I have found to be remarkably uncommon. The literature contains only ten cases wherein both the gross and microscopic descriptions will allow of such a diagnosis. Many cases are erroneously reported as cystic lymphangiomas, that in reality are typical enterocystomas, and some multilocular mesenteric cysts are recorded that fail to show any proliferative changes. Because of the infrequency of true proliferating lymphangiocystomas, it seems to me that the following case is worth recording.

CASE REPORT

G. G. W., male, aged 43, a farmer. On August 21, 1934, he complained of pain in the left upper quadrant. This became gradually worse. Pulse 70, temperature 97.8° F. Abdominal examination revealed nothing except an increase of pain on deep palpation on the left side. There was no rigidity. Repeated hypodermics of morphine were necessary in order to control the pain. There was some nausea but no vomiting. No history of constipation or diarrhea. The following two days, the pain was persistent and of a dull character with no radiation. On the third day of his illness, a firm mass about the size of an orange was palpable in the left lower quadrant, medial and inferior to the iliac crest. Temperature 99.8° F., pulse 76. During the next few days the mass increased steadily in size until it reached the umbilicus and seemed to be centered in the left midline of the abdomen. The tumor was firm and apparently smooth. During this period of observation, the temperature never exceeded 101° F. and the pulse was never over 86. There were no other gastro-intestinal symptoms at any time, and the patient had a normal bowel movement each day.

On the fourth day of his illness he entered the hospital. On physical examination, the findings were practically the same as have already been stated. In the left lower quadrant there was a mass about the size of a grape fruit. It was firmly fixed and slightly tender on palpation, no nodules could be felt, nor could a notch be demonstrated. All the borders were apparently free, and no definite attachment could be

made out. Roentgenographic examination revealed an homogeneous density in the abdomen to the left and downward, and the small intestine lay downward and to the right. A barium enema showed the sigmoid displaced downward and to the left by a mass. No definite filling defects were present in the colonic walls, nor were diverticula demonstrable. The mass was too far to the left for the usual appendiceal abscess. No unusual irritability of the sigmoid was found to suggest ulceration or perforation. Leukocytes 13,900 with 82 per cent polymorphonuclear neutrophiles. The urine and blood chemistry were essentially normal. The Wassermann and Kline tests were negative. The patient's condition improved steadily and he was operated upon on the 17th day of his illness.

FIG. 1.—Photograph of gross specimen showing jejunum opened at the base and large, nodular, hemorrhagic tumor involving the mesentery.

Operation.—Left midrectus incision. A large, red, spongy appearing mass of relatively firm consistency was exposed, which measured approximately eight by six by four inches. In order to mobilize the tumor it was necessary to enlarge the incision in both directions. It was then noticed that there was a torsion of its base in an anticlockwise direction, and that the tumor was apparently involved to the mesentery alone. The mid-portion of the jejunum was overriding the lateral border of the mass so that the latter could not be enucleated; therefore, about five inches of gut on either side of the tumor were resected and a side-to-side anastomosis made.

The postoperative course was uneventful and the patient was discharged 16 days after operation. At the present time, six months after the operation, his condition is normal.

Pathology.—The specimen is a nodular semicystic discolored mass measuring 18 by 16 by 9 cm. There is a section of jejunum bounding the mass along one border and the tumor is growing throughout the mesentery of this section of bowel. The nodulations of the tumor vary in color from a greenish-yellow to a deep blackish-red, and many of them are covered with fine granulations. On section, many of these masses or nodules are cystic and the content of these cysts ranges from clotted blood to a milky semiflocculent material. These small cysts vary in size from .5 cm. to multilocular cavities as large as 6 cm. in diameter, and there is one quite large cavity measuring 12 by 11 by 8 cm. This is lined with a yellowish granular material, and shiny, pale, grayish-white nodulations not much larger than a pinhead are found in clusters here and there on the wall (Fig. 1).

Histologic Pathology.—Sections taken from different areas reveal varying sized cystic cavities, many of which are lined by quite flattened endothelial-like cells. The content of these cavities ranges from a pink staining albuminous precipitate to a frankly hemorrhagic type of material. In the wall of many of these cysts there is fresh hemorrhage, and in some definite fibroblastic type of granulation tissue is seen. Lymphocytes are found in abundance; and occasionally, imbedded within the walls or intervening septa, rather large accumulations of lymphoid tissue are encountered (Figs. 2, 3, and 4).

Diagnosis.—Multicystic proliferating lymphangioma of the mesentery showing a receding inflammatory reaction.

The first case of mesenteric cyst was reported by Beneviene in 1507 as an anatomic curiosity. Various writers have subdivided the history of mesenteric cysts into years as follows: Thus, from 1507 to 1850, this type of tumor was encountered only accidentally at necropsy, while from 1850 to 1880 a few tumors were occasionally observed at operation. In 1880, Tillaux recorded the first operation for this condition, and from this time until 1900 there were only a few recoveries following surgical interference. From 1900 to the present time is the last epoch, in which we find detailed pathologic classifications, perfected surgical technic, many recoveries following operation, and an occasional preoperative diagnosis.

Rokitansky is credited with the first accurate description of a chylous cyst in 1842. This writer attempted to prove the origin of mesenteric cysts from degenerated lymph nodes, with which explanation Virchow agreed in 1887.

The first classification of mesenteric cysts was presented in 1892 by Bracquehaye.[3] His classification included the following groups: (1) Saguinous and serous cysts. (2) Lymphatic cysts. (3) Parasitic cysts. (4) Cysts of adjoining organs. In 1897, Moynihan[4] presented a classification based on the character of the cystic contents, which unfortunately added little to our understanding of this interesting group of tumors. In 1900, Dowd[5] stressed the embryologic origin of these tumors and presented a series of cases collected from the literature. He classified the tumors as: (1) Embryonic cysts; (*a*) dermoid; (*b*) serous; (*c*) chylous; (*d*) hemorrhagic; (*e*) enteric; (2) hydatid cysts; (3) malignant cystic disease. Subsequently, many writers have attempted to elaborate on Dowd's classification. One of the earlier improvements was that made by Niosi[6] in 1907, who further subdivided the embryologic group to include those cysts of intestinal origin which he thought were the result of a sequestration from the gut tract or from the omphalomesen-

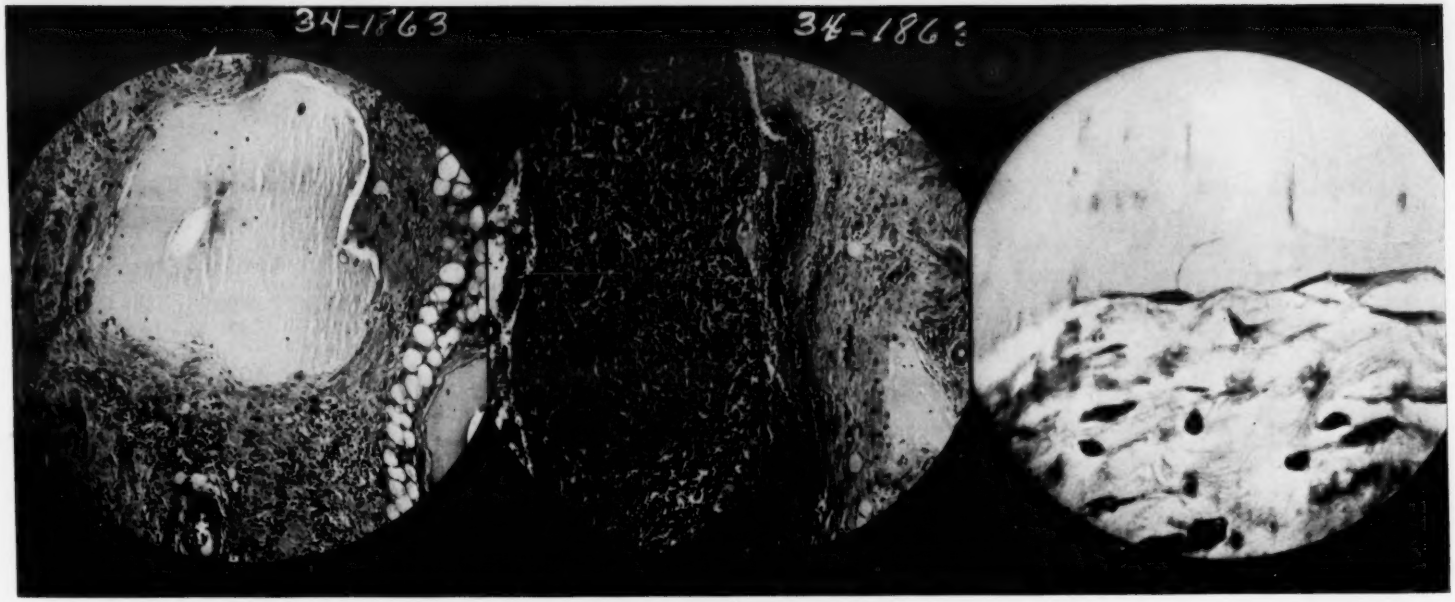

FIG. 2.—Low power photomicrograph showing one of the small lymph spaces filled with lymph; note infiltration of lymphocytes in the wall.

FIG. 3.—Low power photomicrograph of abundant accumulation of lymphoid cells in the stroma of the tumor.

FIG. 4.—Oil immersion photomicrograph of the flattened endothelial lining of one of the lymph spaces in the tumor.

teric duct. Hill,[7] in 1930, was apparently the first to clearly differentiate the true proliferative lymphangiomata from mere dilatation of lymph vessels and he presents an excellent modification of Dowd's classification as follows:

- Congenital
  - Simple
    - Serous
    - Chylous
    - Irregular ..... Occlusion of Meckel's diverticulum
  - Neoplastic
    - Ectoderm ..... Dermoids
    - Mesoderm ..... Lymphatic ..... LYMPHANGIOMA
    - Mesoderm ..... Wolffian
    - Entoderm ..... Enterocystoma
    - Teratoma ..... From fetal inclusion

Since many writers apparently disagree on the exact definition of the term lymphangioma, it is assumed in this discussion that the word is synonomous with a true neoplastic process involving the lymph vessels, with their endothelial cells and supportive connective tissue, in contradistinction to a simple dilatation of preexisting lymph vessels. The latter should be considered as lymphangiectasis and not as a true neoplastic process. Apparently a large number of cases of lymphangiectasis are reported in the literature under the erroneous classification of lymphangioma.

In reality the term mesenteric cyst covers too broad a field. Any condition found in the mesentery and presenting any cystic characteristics whatever is usually classed as a mesenteric cyst. This should not be so. The term is correct insofar as the location is concerned, but it is very misleading from a clinicopathologic standpoint. Very frequently, when considering conditions of a rare and obscure origin, the classification and terminology found in the literature are as unsatisfactory and diverse as the many attempts to explain the process. This is especially applicable to true lymphangioma of the mesentery.

Pathogenesis.—Many theories have been advanced in an attempt to explain the presence of lymphangiomas and cysts of the mesentery. As was previously mentioned, the first reference to these tumors was made by Rokitansky whose opinion was supported by Virchow. They held that these cysts were due to degeneration of lymph nodes. The theory of stasis and retention of lymph in preexisting lymphatic vessels has been advocated by some of the earlier writers. Other authors have attributed these cysts to obstruction of the various lymph channels (Killian, Bramann, Tilger and Hlava, quoted from Hertzler[8]). This theory is certainly untenable because of the existence of many and very extensive anastomoses of the lymph vessels where they do occur. The experimental work of Hertzler[8] showed only a peritoneal exudate after complete ligation of the thoracic duct. Dowd[5] also

states that lymphatic cysts do not occur after complete obliteration of the thoracic duct.

Dowd[5] pointed out in 1900 the close relationship between the wolffian body and the genital ridge to the root of the mesentery in fetal life; and he showed that it was possible during this period for a sequestration of cells from the germinal epithelium to become displaced and assume an intramesenteric, mesocolon or mesorectum position. Later in life, such a group of cells may become active and form a tumor. Dowd also pointed out the further possibility of such a sequestration of cells from the gut tract becoming dislodged and gaining position in the mesentery, thus forming a tumor of intestinal origin. As stated by Hertzler,[8] this theory may explain cysts found in certain locations but can not account for all the regions where these tumors are found. Some writers believe that trauma may have some influence in their development, while others are of the opinion that inflammatory changes may be of etiologic significance. Fisher[9] reports a case of lymphangioma of the omentum, which he considered to be due to a metastatic infection producing lymphangiectasis which later was initiated by an attack of tonsillitis several years previously. Outerbridge,[10] in reporting a similar case, agrees with Fisher that a large number of lymphatic cysts may be of an inflammatory character. Ewing[11] states that a chylous angioma is due to either congenital or acquired obstruction to the lacteals, which explanation could undoubtedly account for all except the rare neoplastic proliferative types.

One of the most convincing hypotheses to account for the pathogenesis of these tumors is that which holds that they are due to congenital malformations of the lymphatics. Arzela[12] contends that the embryologic defect is an error in the early formation of the lymph nodes, while other writers believe that they arise from a primary lymphatic analage. Ranvier[13] has noted such misplaced islands of tissue in the mesentery of his newborn pigs and cats. Moreover, lymphangioma has been found associated with lipoma (Ewing), while Ritschl[14] has found an island of cartilage in an intramuscular lymphangioma.

There are several cases of true enterocystoma erroneously reported in the literature as lymphangioma. The embryologic origin of enterocystomas is well proved. Miller,[15] in an article on enterocystomas, records such a cyst which he observed in a four-day-old infant. The wall of the cyst was in part directly continuous with that of the jejunum, and histologically the cyst wall closely resembled that of the adjacent gut. Palmer[16] also reports a case of an infant eight days old with a mesenteric cyst in the wall of which transverse and longitudinal involuntary muscle was encountered. These cases apparently establish the enterogenous origin by a sequestration during embryonic life.

The exact mode of formation of these tumors may depend on the as yet unexplained phenomena involving the formation of lymph. The question arises as to whether the endothelial cells actively secrete or merely conduct lymph, or whether both functions are included. Adami[17] makes the statement

that endothelial cells under pathologic conditions probably secrete lymphatic fluid.

Symptoms and Diagnosis.—It has frequently been stated in the literature that the diagnosis of a mesenteric cyst has never been made prior to operation. After a careful review, however, I was able to find four cases in whom the preoperative diagnosis was made and proved at operation. Three clinical diagnoses were made by the process of exclusion, and one was made by Parker[18] from roentgenographic studies alone.

There are no definite signs or symptoms which are pathognomonic of mesenteric tumors. Naturally, the outstanding feature of the physical examination is the presence of a palpable mass which may be in any location in the abdomen. Usually these tumors are situated in the lower abdomen, and more often are near the midline. Most writers stress the extreme mobility of the mass, especially in a transverse direction. The reported cases give a most variable history. The usual predominant symptoms are severe pain, flatulence, and signs of obstruction. Frequently, a history of repeated attacks of pain is given, often associated with alternate intervals of constipation and diarrhea. Some writers have stressed cachexia as an outstanding manifestation. Obstructive symptoms are usually due to pressure on the intestinal tract which is flattened out over the mass as a ribbon; or the tumor by its own weight may drag down on the gut, causing obstruction. A change in position of the mass may also easily cause a kink in the intestine. Torsion may likewise cause acute symptoms, as may trauma and infection. It is quite possible for pelvic symptoms to predominate if the tumor is low, thus causing pressure on any of the pelvic structures. The size of the tumor has a most important bearing on the symptoms. Thus, it is easily seen that small tumors may give rise to few if any symptoms. Both of Hertzler's[8] cases were discovered while operating for other conditions. An attempt at differentiation must be made between ovarian cysts, tumors of the liver, tumors and displacement of the kidney, retroperitoneal and uterine tumors, cysts of the pancreas and tumors of the intestinal tract. Roentgenographic studies should be made in all possible cases, as one of the four preoperative diagnoses was made in this manner. Any diagnosis will, of necessity, be made by a process of exclusion.

Treatment.—The treatment of mesenteric tumors is always surgical, and an acute obstruction may constitute an emergency. In operation for this condition, one has the choice of five different procedures, although only enucleation and resection seem to have any real merit. Drainage, aspiration, and marsupialization are unsatisfactory and can not give consistently good end-results. Drainage frequently leaves a persistent draining sinus, which often requires a resection later. Aspiration was used by the older surgeons but today is wholly unsatisfactory. Marsupialization is also a method to be discarded as obsolete unless used as a palliative procedure when the condition of the patient will not allow further surgical interference. Enucleation is, of course, the method of choice when possible. If the tumor can be completely

enucleated without damage to the adjacent gut, or without too extensive impairment of the immediate circulation, the results may be satisfactory. Only one rare occasions is it possible to enucleate a true lymphangioma. The operative mortality of this procedure has been estimated by Flynn[19] to be about 16 per cent. In a majority of cases, resection is necessary in order to remove the tumor successfully. In the uncomplicated cases, the mortality of this procedure probably runs in direct ratio to the ability of the surgeon. One writer reports a series with a mortality of 60 per cent which seems to be unnecessarily high. No doubt such a high mortality is due in large part to the condition of the patient when operated upon and to complications already present at this time; for example, an absolute obstruction of some duration with a possible complicating peritonitis. In uncomplicated cases, there is no reason why this mortality should be any higher than in the usual run of intestinal resections.

Prognosis.—The prognosis of these purely benign tumors of the mesentery is quite favorable, notwithstanding the many pessimistic views presented in the literature. Any growth which showed any gross or microscopic evidence of malignant change naturally would not come under this benign grouping.

Report of Cases from the Literature.—No doubt there are other cases of true proliferative lymphangioma which have not been reported. Perhaps some tumors of this type already reported have been omitted from this paper but the very meager and inadequate gross and microscopic descriptions would not permit of their inclusion. A number of cases are classified as lymphangiomas which in reality are merely lymphangiectases, and many cases are encountered which are undoubtedly enterocystomas.

(1) The earliest lymphangioma was reported by Weichselbaum[20] in 1875. The tumor resembled a lipoma and was located high in the ileum, between the leaves of the mesentery. The gross and microscopic descriptions are excellent. The tumor was found at necropsy.

(2) Flynn[19] reports a case of a white girl, aged 16, admitted to the hospital acutely ill, with a history of abdominal pain, nausea, and no bowel movement for three days. The patient had cramping pains associated with nausea for several weeks before admittance. There was a history of a severe blow in the left lower quadrant about six years prior to this illness. One year previous, it was noticed that the abdomen was enlarging. At operation a mesenteric mass was found just below the ligament of Treitz, in the upper part of the jejunum. The size of the tumor was 20 by 12 by 12 cm. and was of a spongy consistency. The tissue cut with little resistance, and consisted of numerous cystic spaces. Microscopic examination showed numerous channels of varying size. Between the channels there was considerable connective tissue, showing lymphocytic infiltration. The channels were all lined with endothelium. Operation—resection with 40 inches of gut. End-result—recovery.

(3) Royster[21] reported a case in a boy 13 years of age. There was a marked hyperplasia of some of the large lymph nodes, in addition to the

primary growth. The mass was resected along with 54 cm. of gut, but the end-result was not stated.

(4) Crane[22] reported a tumor composed of spongy lymphangiomatous tissue in a man 39 years old. The growth evidently was a true lymphangioma although his description is quite brief. The mass was enucleated and the patient recovered.

(5) Hill's[7] case is a classical lymphangioma of the mesentery. It was impossible to enucleate the tumor, and the patient died.

(6) Wade and Steigrad[23] have reported a case in a girl three years old. Their very brief description is wholly inadequate, but I believe the tumor to be a true proliferating lymphangioma. The mass was resected, with recovery of the patient.

(7) Rawls[24] reports the case of a boy aged 13. In this instance, th lymphatics surrounding the tumor showed a simple hypertrophy. The mass was resected, and the patient recovered.

(8) Collins and Berdez[1] have reported two cases. The first was seen in a boy four years old. The tumor was so extensive that no resection was attempted and the patient died.

(9) Their second case was that of a woman 48 years old. The involvement was so extensive that resection was impossible and the patient died.

(10 and 11) Hertzler[8] has encountered two such cases accidentally while operating for other conditions. Both tumors were found in males, one man about 59 years old and the other 30 years of age. In a personal interview, after examination of the gross and microscopic specimens of the case reported in this paper, he stated that his two cases were of the same type.

SUMMARY

(1) A true proliferating cystic lymphangioma of the mesentery of unusual size is reported.

(2) This tumor had the exact displacement of Flynn's tumor; namely, 20 by 12 by 12 cm., the largest true lymphangioma on record.

(3) Many cases are erroneously reported in the literature as lymphangiomas which in reality are merely lymphangiectases or enterocystomas.

(4) Only 11 cases of true proliferating lymphangioma of the mesentery were found, and a careful review of the literature on the subject has been carried out to eliminate those cases which do not conform to this type of growth.

The author wishes to thank Dr. L. P. Engel for the use of this material and records, and to acknowledge especially his indebtedness to Dr. F. C. Helwig for the pathologic description of the tumor, also for his many helpful suggestions and aid in the preparation of this paper.

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Lack of space does not permit the listing of the complete bibliography here but it will appear in the reprints.

CONSERVATIVE TREATMENT OF ACUTE HEMATOGENOUS OSTEOMYELITIS *

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THERE are many surgeons who advocate an immediate operation, usually bone decompression, for acute hematogenous osteomyelitis, and by "immediate" I mean an operation within hours of the time that the diagnosis is made. To this group there are few contra-indications to the method; to them the operation is more urgent and exposure of the medulla more necessary *pas et pas* with the severity of the symptoms. Seldom does one hear or read any criticism of the method, an absolution that is inexplicable in the face of the 20 per cent mortality (Table I). The loss of every fifth patient should cause one to question whether the treatment is too radical. Does this immediate decompression disregard the patient? I believe it does, and to such an extent that the patient becomes a battleground in the war between the surgeon and the infection. I hope to prove that when the surgeon is conservative, when he confines his activity to the supply of ammunition, the patient's defenses more often will confine the attack.

TABLE I *

	Number	Deaths	Mortality Bone %	Mortality Series %
Femur	37	8	22−	30
Ulna	3	1	33	4−
Radius	3	2	60	8−
Pelvis	4	0	0	0
Os calcis	7	1	14+	4−
Fibula	8	0	0	0
Humerus	9	3	33	11
Tibia	50	11	22	43−
	121	26	21.49	100

* Does not include four cases not operated upon which died.

The principal argument advanced against conservative treatment is the theory of the pathology of the disease. It is alleged that all these infections arise in the metaphyses, from which points, because of compression by the rigid bony cortex, there is a spread throughout the medulla. Emphasis is placed on the dissemination because it destroys bone and also as the pus tension increases with the spread, sepsis will be multiplied. If this theory of genesis and contamination be true, conservative treatment, at first glance, would seem to be hopeless; action, imperative action such as immediate de-

* Read before the Philadelphia Academy of Surgery, April 1, 1935.

compression, might appear to be mandatory. The choice between the two methods, the radical and the conservative, will depend to some extent on the validity of that theory. After all, what proof is there that this explanation of the pathology has the dignity of a theory?

If the experimental evidence of the constant metaphyseal origin of this infection is to receive any credence, it must be supported by clinical observations. In a search for such corroboration, I have studied the histories of all the cases of acute hematogenous osteomyelitis treated in the Episcopal Hospital from January, 1911, to June, 1934, 121 cases in all. The location of the pus was recorded in 117 of this group, and of that number, in only 12 (Table II) was there a record of a solitary intra-osseous collection—not very strong evidence of the constancy of an initial attack within the bone. It is true that there were 24 other cases with pus in the medulla but in all of these cases there was also pus in the subperiosteal space. It is possible, as will be noted later, that the record about the pus within the bone might have been due to the desire to find it there; however, add these 24 to the 12, believe if you wish that there were 36 initial intra-osseous infections, and still you will lack evidence to support the argument for radical treatment in *all* of these infections.

TABLE II

LOCATION OF PUS (117 CASES)

Pus in bone only	12
Pus in bone and beneath periosteum	24
Pus beneath periosteum only (incision—no decompression)	42
Pus beneath periosteum only (confirmed by decompression)	39

The theory of the metaphyseal or intra-osseous genesis of the infection becomes more uncertain as the analysis of the 117 cases progresses. Thirty-six of the cases were discussed in the previous paragraph, so that 81 remain in the study. In all of these 81, pus was found in the subperiosteal space. In 42 of the 81, for one reason or another, the bone was not opened. In the other 39, the medulla was exposed and no pus found. To repeat, there were 39 cases of acute hematogenous osteomyelitis in which pus was found beneath the periosteum but no pus inside the bone, evidence that many of these infections started outside the cortex. I will concede that there may have been errors in observation and recording but they might have occurred in any of the three groups, the intramedullary, the combined intramedullary and subperiosteal collection or the isolated subperiosteal. The observations were made by eight surgeons, to seven of whom the intramedullary origin of the infection was almost a religion, and it seems as probable that they recorded pus when gray marrow or fat was seen, as it is probable that they missed pus when it was present. Discredit the observations of clean medulla any way you wish and still you will be faced with the fact that in the 81 cases just discussed plus 24 mentioned in the previous paragraph, a sum of 105 cases out of the 117 studied, *there was pus beneath the*

periosteum, and if this be not an argument against intra-osseous origin of the infection, then it does become evidence that the pus finds an exit, that decompression occurs, and that spread of the infection can be limited without surgical intervention.

While making this study, I gathered the impression that if I could find records of cases operated on in the early stage of the disease, the operative findings in these cases would be more indicative as to the original focus in or around the bone. I found such cases, four of them, operated on within 48 hours of the onset of symptoms, and in all four there was no pus in the medulla though there was pus in the subperiosteal space. If any explanation other than the subperiosteal origin be accepted, then one is face to face again with control of spread by spontaneous decompression, and an early one too.

The statistical study is not the only source of doubt against the metaphyseal origin in *all* cases. There is also the relationship of trauma to the disease. By trauma is meant a blow or fall or kick which is sometimes mentioned as a direct antecedent to the onset of symptoms and such trauma has been accepted as an etiologic factor. How does it act? Probably by injury to the periosteum for the reason that an injury to the medulla would occur as the complication of a fracture of the cortex, and few of these blows are of sufficient violence to do that; in fact, seldom does one see any external signs of the blow or kick, not even an hematoma. It is as easy to explain the connection between the trauma and the infection by assuming damage to the periosteum as it is to assume any other locus minoris resistentiae. A blow to the periosteum would destroy tissue and release histamine, which in turn acting as a dilator of the vessels would retard circulation and allow bacteria to be dropped out to feed on the weakened area. The fact that end arteries are prominent in the metaphysis does not limit localization of infection to that area; end arteries can be manufactured by a rupture of the vessels of the periosteum, and even though these are only end arteries for a short period, deposition of bacteria could occur in that period. Of course, this is all argument, it does not prove where the infection starts after trauma, but the evidence for the subperiosteal origin is at least as strong as the evidence for the intramedullary genesis.

The origin of the disease is of importance in the determination of spread of infection. In those cases where the pus is formed outside the bone, there will not be any rapid spread within the medulla; this is obvious. Though not so obvious, I believe it is equally true that there need not be a wild-fire contamination of the medulla in every case where the pus is within the bone and confined by it. It seems to me that spontaneous decompression of the bone is an actual occurrence and that it can thereby limit spread of infection or neoplasm. In malignancies metastatic and primary, this occurrence seems to be the explanation when the growth perforates the cortex before the entire bone is involved. If there really was an intramedullary origin in the 24 cases of Group 2 in Table II, those cases where there was

pus inside and out, then the subperiosteal pus was an accumulation from the medulla probably through a hole in the cortex. Even if there be no such safety valve as spontaneous decompression, immediate surgical decompression is unnecessary in all the cases when at the most only about one-half, and probably only one-sixth, of the records showed pus confined by bone.

And so this study, statistical and deductive, offers evidence that many infections in acute hematogenous osteomyelitis do arise outside the medulla —thus, the basis for the radical treatment in every case of this disease is not a sound theory, contrariwise, it is not more than an hypothesis.

The proponent of the conservative treatment must do more than discredit the basis on which the radical treatment rests. He must show that the latter method is actually harmful. That it could be dangerous where there is localized subperiosteal pus needs no argument since exposure of the medulla, a measure in that method, would carry infection from the contaminated area into clean tissue. Just what effect this contamination has on the mortality figures would be difficult to determine, but from the study of the 39 cases (Table II) where exposure of the clean medulla was done through subperiosteal pus, there was a mortality of 40 per cent after drilling and 35 per cent after guttering. Contrast these figures with the 5 per cent mortality in the 42 cases where the operation was limited to incision, where the medulla was not exposed after finding the pus; the difference in the percentages is so great that there can be no denial of the fact that exposure of the medulla in every case is a hazardous procedure. Not all of the deaths in the 39 cases can be attributed to the bone decompression per se; some of these deaths were due to the stage of the disease in which the operation was done—in other words, some deaths resulted from the principle of operating "as soon as possible."

The "as soon as possible" operation may be either early or late in the disease, depending upon the time of the diagnosis, but as related to admission to the hospital, it is immediate. Thus, there may be an immediate late, delayed diagnosis and a hurried operation, or an immediate early operation which, under the radical treatment, is considered the ideal plan.

Recourse to the 121 cases already mentioned will show that neither the immediate operation nor the early operation accomplished all that it was supposed to do, that neither operation nor even the combined immediate early has been ideal. Here are some of the facts gathered from the study of these cases, *viz.*:

(1) The immediate operation mortality rate was 26 per cent as compared to the 15 per cent mortality for the delayed operation (Table III). (The term delayed operation signifies an operation any time after the first day in the hospital.)

(2) The early operation when performed within four days of the onset of symptoms was accompanied with a mortality of 39 per cent (Table IV).

(3) The operation done in the first week of symptoms (still early operation) failed to save 35 per cent of that group (Table IV).

TABLE III *

TYPE OF OPERATION AND MORTALITY

	Cases	Deaths	Percentage	
Immediate évidement †	32	10	31	
Immediate drilling †	18	6	33	26%
Immediate incision	18	2	11	
Delayed évidement ‡	15	4	26	
Delayed drilling	14	4	28	15%
Delayed incision	24	0	0	

*Represents the work of eight surgeons.
†Immediate—within 24 hours of admission.
‡Delayed—after 24 hours of admission.

(4) In the second week of the disease the operative mortality was 3 per cent (Table IV).

(5) After the second week of the disease the mortality rises to 15 per cent (Table IV).

TABLE IV

TIME OF OPERATION AND MORTALITY

Operation from Onset	Number	Deaths	Percentage for the Day
Within 4 days	18	7	39
5th–7th inclusive	35	12	34
8th–10th inclusive	12	1	8
11th–14th inclusive	18	0	0
15th–21st inclusive	10	2	20
22nd–30th inclusive	10	2	20
Over 30 days	18	2	11
	121	26	21.49

These facts show the mortality in the early operation is twice as high as the late one. Thus, the accurate diagnosis was a curse to the patients. The late cases had a mortality that was too high and from the study it seems that this mortality rate might have been improved by an operation in the second week of the disease, that period in which there was a 3 per cent mortality. The failure of the so called ideal plan, early and immediate operation, was due to neglect of and disrespect for the patient's defenses.

Consider the patient for a moment. Usually it is a child that is stricken. For a few days, or many, this child has suffered excruciating pain, has lost sleep, and has had fever, sometimes excessive. The patient's margin of reserve has been strained by suffering, insomnia and dehydration. Then there enters into the picture the element of fright, fright of transfer to a hospital. It is useless to depend for restoration on one dose of morphine given preoperatively and the supplemental hypodermoclysis, nor can there be any soothing by the hurried preparation for the operation. As frightened and as sick as it is, this child, if it is to receive the benefits of the immediate operation, must still face the unpleasant experience of anesthesia, must still

face the loss of more fluid at the operating table and from the wound, and must still face the danger of the contamination of clean tissues. In short, the uncorrected shock of infection is augmented by the shock of operation. It seems to me that the immediate operation in acute hematogenous osteomyelitis must weaken the depots which supply the local defenses against the invader.

Now, let us turn to the infection and its relation to the time of operation. The early operation, immediate or delayed, probably acts as an adjunct to the infection. In this stage, the spreading one, nature is attempting to wall off the bacteria and is making an effort to localize the attack. At this time, even an incision will open lymphatics in clean areas and through them toxins have easy access to the general circulation. The early operation does more than that; it affords additional food for the organisms in the form of surgically devitalized tissues. It is not only in acute hematogenous osteomyelitis that there is danger in early operation; there is the same danger in any spreading infection, and it has been particularly emphasized in infections of the face and hand.

In addition to the hazard of disseminating the infection by the early operation, there is the possibility that in a child suffering from bone pains and fever, hasty operation may cause embarrassment. Years ago Murphy made the statement that unless all cases of osteomyelitis were operated upon within 24 hours of onset of symptoms, bone necrosis was sure to follow. Such a drastic procedure in every case of bone pains will cause some cases of osteomyelitis, and has caused it. In the 121 cases studied here, no pus was found in the medulla or beneath the periosteum in three cases; these children did not have osteomyelitis before operation. In a fourth case, not included in the study, the final diagnosis was sarcoma. Not all cases of bone pains are due to osteomyelitis and it would be better to find pus at a late operation rather than no pus in an early operation.

I realize the facts that I have adduced in the previous paragraphs about the higher mortality in the early and in the immediate operation have not eliminated the possibility that these deaths occurred in the very ill patients, in those in whom the mortality would be higher. Let us take the tempera-

TABLE Va

TEMPERATURE, OPERATION AND MORTALITY

Operation Within Seven Days of Onset

	I.E.	Death	D.E.	Death	I.D.	Death	D.D.	Death	I.I.	Death	D.I.	Death
Over 105	5	5	0	0	1	1	0	0	1	0	0	0
103–105	7	4	3	3	5	1	2	2	0	0	2	0
102–103	1	0	0	0	4	2	0	0	2	0	1	0
	13	9	3	3	10	4	2	2	3	0	3	0

34 cases with 18 deaths—53%

I—Incision or Immediate. E—Évidement. D—Delayed or Drilling.

ture range as an index of severity (there were too few leukocyte counts to use as an index) and analyze the mortality as affected by the early operation in the temperature ranges between 102° and 106° F., in those patients who were the sickest.

(1) There were 34 patients (Table Va) with a temperature above 102° F. who were operated upon within seven days of onset; 18, or 53 per cent, died after operation. In the same temperature range, but operated on after seven days of the disease, there were 24 cases and six deaths (Table Vb), an operative mortality of 25 per cent. In summation, the mortality was twice as high in the early operation on the sick patient as it was in the delayed operation for the same class.

TABLE Vb

TEMPERATURE, OPERATION AND MORTALITY

Operation after Seven Days of Onset

	I.E.	Death	D.E.	Death	I.D.	Death	D.D.	Death	I.I.	Death	D.I.	Death
Over 105	0	0	0	0	0	0	0	0	0	0	0	0
103–105	6	1	2	1	1	1	0	0	1	0	1	0
102–103	4	0	2	0	3	1	2	2	0	0	2	0
	10	1	4	1	4	2	2	2	1	0	3	0

(2) Between 103° and 105° F., there were 26 operations and 16 deaths, 61 per cent, for the early operation, and for the operation after the first week in the same temperature range, there were 11 cases with three deaths, 27 per cent mortality. Thus, the early operation in the very sick cases had more than twice as high a mortality rate as the late operation.

(3) There were no cases with a temperature over 105° F. operated upon after seven days of onset but there were seven early operations and six patients died, 86 per cent. The mortality rate could hardly have been worse than this 86 per cent if the operations had been delayed a week.

Most assuredly the sicker cases were the ones that died in the early operation, but they died not only because of the severity of the illness, but also due to the fact that they were operated on when they were so ill.

Thus we come to the first regulation of the conservative treatment in acute hematogenous osteomyelitis and that is, delay the operation until the patient's resources have been repaired by rest, transfusions, infusion and acclimatization to the hospital; give the patient the ammunition he cannot supply. The second desideratum of the treatment is, do not operate until the local battle has been confined, and in this study the optimum time would seem to be in the second week of the disease. The third measure is, limit the operative procedure to incision only—*do not decompress* at the first operation.

Here are the statistics of this study which argue for incision as against bone decompression, *viz.*:

(1) For 47 cases of évidement or guttering, the mortality was 29 per cent (Table III).

(2) For 32 cases of drilling, the mortality was 31 per cent (Table III).

(3) In 42 incisions, the mortality was 5 per cent (Table III), one-fifth of guttering and one-sixth of drilling.

(4) Guttering and drilling were accompanied by 100 per cent mortality if the temperature was over 105° F. (Table VI).

TABLE VI

Temperature	Number of Cases	Deaths	Percentage
106° F.	3	3	100
105°–106° F.	4	3	75
104°–105° F.	14	5	35
103°–104° F.	16	8	50
102°–103° F.	21	5	23
Under 102° F.	63	2	3+

(5) *The only case that recovered with a temperature over 105° F. was after incision.*

(6) Bone decompression in the first seven days when the temperature was over 102° F. had a mortality of *64 per cent.*

(7) There were six incisions in the first seven days in patients with a temperature over 102° F. and *no deaths.*

(8) Over 102° F. and after seven days, the mortality rate was 30 per cent for decompression.

(9) In the same temperature range and period, there were four incisions and no deaths.

The gist of this analysis shows that decompression is a decimating procedure in the early phase of acute hematogenous osteomyelitis and incision is a safer measure at any time, preferably not immediate.

There are a few cases where the pus will be located in the medulla only and for these incisions alone will not suffice. In these, after the incision has been made, pack the soft part for 48 hours and then open the bone.

I feel sure that conservative treatment will permit the patient to wage his own fight in a more efficient manner. I believe that a study of the cases treated by the radical method confirms that.

THE ORR TREATMENT OF PYOGENIC OSTEOMYELITIS

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THE adequate treatment of pyogenic osteomyelitis must continue to hold the interest of the medical profession. It is significant that perhaps the major portion of the literature on this subject reflects the general surgical viewpoint rather than the broader orthopedic concepts upon which Orr has based his system of treatment. The residual disabling deformities resulting from osteomyelitis are so common that our therapeutic responsibility does not end with the initial surgical intervention. The postoperative care is of the greatest importance in terminating the disease to the patient's best interests. Experience with pelvic localizations of this disease, as well as with suppurative joint lesions and associated conditions, fortifies one's confidence in the Orr principles of treatment. The radical measures, so essential in the attack upon pelvic foci, would not be feasible otherwise.

It is essential to emphasize that both of Orr's major premises—adequate drainage and adequate rest—are equally important; and that neither one alone is sufficient or can be subordinated to the other. This needs special emphasis because the method is so appealingly universal that there is, to my mind, some tendency toward technical neglect. Experience and the most careful attention to details are of primary importance in the successful treatment of pyogenic osteomyelitis. This requirement must be realized before one undertakes the problem, as its fulfilment may well tax the ingenuity and patience of the surgeon to the utmost.

It is not surprising that diametrically opposed principles are advocated in the treatment of pyogenic osteomyelitis and allied suppurative processes. The variable methods of treatment indicate the interest of the profession but nevertheless cause confusion. From experiences during the Great War, there were evolved paradoxically enough three principal methods of treatment; the chemical antiseptic of Carrel-Dakin, viable antiseptic maggot therapy of Baer, and the Orr method. This divergence of opinion, more apparent than real, was no doubt conditioned by the exigencies of war conditions. Possibly because, "in the craft of surgery the master word is simplicity," and for one reason or another, antiseptic methods are steadily losing ground in the treatment of infected wounds.

An important fundamental lesson learned from experience with the Orr method is that *pyogenic osteomyelitis—regardless of its localization—is not a surgical condition per se until the diagnosis is made; when some degree of suppuration has developed.* The student of osteomyelitis is gradually impressed by the fact that the many variable and unusual manifestations of the

disease are of relative importance only, and that there is a harmony when viewed from the proper perspective. Orr's dictum of operation, just as soon as the diagnosis is made, simplifies the problem because no distinction is made between acute, chronic, or other unusual phases of the disease.

General Discussion of Treatment and Approach to the Radical Methods of Attack.—This series is convincing proof that the ideal to be attained in the treatment of this disease is a complete eradication of the infectious bony focus whenever possible. Such factors as stage of the disease, number of lesions, complications, extent of the lesion, the patient's operative risk and above all the presence or absence of suppuration may require consideration. It may be axiomatically stated that operative intervention depends primarily upon the presence of suppuration. Let us remember that not infrequently the lesion is nonsuppurative, and occasionally spontaneous healing may and does take place, especially when the focus is metastatic. The main argument centers, however, upon the fact that pyogenic osteomyelitis is essentially a most devastating disease, which must be combatted by bold, aggressive, radical, operative measures.

The fact that acute hematogenous osteomyelitis, in any situation, is essentially and primarily a septicemia, cannot be overemphasized. The local skeletal manifestations of the disease are not surgically significant until a diagnosis can be made with a reasonable degree of certainty; when suppuration, or its definite tendency, can be clinically determined. The early discriminating diagnosis is dependent chiefly upon the observer's experience with the disease, and his degree of osteomyelitis consciousness. It is a fact that the vast majority of cases as seen in private and clinic practice are not recognized before rather obvious local signs are manifest, even in the ordinary long bone situations. Still more unfortunate is the victim of an unusual localization of the disease. Therefore treatment at the onset must be directed against the general systemic infectious invasion, being ever on the watch for localizing skeletal signs and symptoms.

There is more or less general agreement for radical excision of the involved parts in chronic and even in some subacute forms of the disease. However, acute osteomyelitis is presumably not adaptable to such measures. The reasons given are usually increased mortality and morbidity, and the difficulty in determining the limits of the lesion surgically. There is no proof that direct drainage of the bone in the acute stages increases the death rate. In most situations the changes in the bone subsequent to thrombo-embolic ischemia are evident very early in the disease after adequate operative exposure. At any rate, the division into acute and chronic stages is of more academic than practical surgical significance because the problem is quite evident when the diagnosis is made. Patients who die in the very early stages of the disease are overcome by the overwhelming sepsis. Until we know more about the relationship between the port of bacterial entry, the septicemia and the local skeletal manifestation, it would seem that adequate drainage should be instituted as soon as the diagnosis is made. The bony lesion should

be attacked whenever this can be located. This is particularly true in some situations because our pathologic studies indicate that extensive collateral changes take place secondarily throughout an entire bony segment from even well circumscribed initial destructive foci. A study of such unusual localizations as the pelvis points out and emphasizes several factors in the management of the disease as practiced inadequately by the rank and file of physicians.

Timidity, indifference, or ignorance are reflected in the treatment many of these patients received before their admission to the hospital (pelvic). Of the 29 sacro-iliac lesions, three drained spontaneously, the abscess was incised in seven instances and aspirated in two. The bone was not attacked in any of them and the rest received no treatment at all. Of the 21 ischial foci, three drained spontaneously, five received incision and drainage and the bone was curetted in one. Of the 29 iliac lesions, bony curettage was performed in four, simple incision in four and nine drained spontaneously. Of the four sacral foci only one had a soft tissue drainage. The coccygeal focus went undiagnosed until after admission to the hospital, when adequate treatment resulted in cure. Almost the same might be said of an equal number of cases involving more usual long bone localizations of the disease, particularly the femur.

I am convinced that the vast majority of cases are pitifully undertreated, As one becomes familiar with the disease he is more and more ready to adopt the most radical measures to attain a cure. The affected portion of bone should be removed no matter in what stage of the disease it is encountered at operation. No distinction should be made between acute and chronic stages of the disease in this situation in properly selected cases. The general condition of the patient and operability of the lesion should be our guide in the surgical procedure. In the subacute and chronic stages the need for radical removal of affected bone must be accepted. Now the lesion is obvious, and the operative indication is more definitely planned.

The following remarks are based upon 323 cases of pyogenic osteomyelitis treated by the Orr method up to September, 1934, in Doctor Steindler's Clinic and also on several private cases of the author's. The technic as discussed pertains to all localizations of the disease. Spinal and pelvic localizations, however, have been briefly considered elsewhere and will be taken up in detail at some later date. Aside from anatomic technical differences, the principles of treatment remain the same in all foci of the disease. The following analysis (Table I) illustrates the essential data in this series of cases, which does not include a number of instances of suppurative joint lesions, associated suppurative conditions and pyogenic osteomyelitis due to the more unusual bacterial organisms, which were treated by the Orr method. The vast majority of cases will fall into the subacute or chronic phase of the disease.

Surgical Technic.—*(Long bones) (1) Approach.*—The most direct incisions are utilized. Incisions should be planned accurately, even in acute

TABLE I

GENERAL ANALYSIS OF CASES TREATED BY THE ORR METHOD

Site of lesion	Total number	Healed	Still under treatment	Practically healed	Result unknown	Amputation	Deaths
	323	210	40	27	34	6	8
		(65%)	(12.38%)	(8.35%)	(10.52%)	(1.85%)	(2.46%)
Femur	92	43	17	14	13	2	3
Tibia	80	53	14	8	3	2	0
Foot	26	21	1	1	3	2	0
Hip	24	13	2	2	6	0	1
Os calcis	15	12	1	0	2	0	0
Spine	13	10	0	0	1	0	2
Humerus	12	9	0	0	3	0	0
Knee	10	10	0	0	0	0	0
Sacro-iliac	10	8	0	0	0	0	2
Ilium	4	3	1	0	0	0	0
Ischium	5	4	1	0	0	0	0
Tibia and fibula	6	6	0	0	0	0	0
Fibula	5	1	2	1	1	0	0
Radius	7	5	1	1	0	0	0
Ulna	4	4	0	0	0	0	0
Hand	4	4	0	0	0	0	0
Scapula	1	0	0	0	1	0	0
Patella	2	2	0	0	0	0	0
Elbow	1	1	0	0	0	0	0
Cavicle	2	1	0	0	1	0	0

cases, if care is taken to determine the site of greatest tenderness, edema, infiltration or swelling. The metaphyses are the chief sites of predilection of the disease. Roentgenologic examinations from various angles may often disclose abnormalities in density and bony architecture, even in very early cases. It is essential, however, to avoid if possible proximity to important vascular structures. Dissection is rapidly carried down to the depths either between muscle planes or by sharp dissection through the muscles and fascia. All the soft subcutaneous tissues must be incised equally in length to the skin. Funnel-shaped overlying soft tissue operative sinuses promote a too rapid extrusion of the pack in deep situations. A generous incision will allow healing to proceed from the bottom, without permitting premature closure of the soft parts. Incisions made the entire length of the limb are sometimes indicated. This is determined by the underlying extent of the pathology, and by the general condition of the patient. The resultant scars do not necessarily interfere with function later. If old sinuses and scarred areas are present it is wise to excise them in order to establish a subsequent healthy basis for the growth of granulations. An approach to the diseased area through a thick layer of soft tissue also insures abundant granulations. Drainage will be facilitated by placing incisions in the dependent parts whenever feasible. *Counter incisions should always be employed in infected compound fractures, in which situations the jagged bone ends have perforated muscle and fascial compartments.* All

fascial compartment invasions must be evacuated. The periosteum is now generously incised but stripped only enough to afford adequate access to the diseased bone. The periosteum should be preserved as far as possible. Evacuation of a subperiosteal abscess alone is rarely sufficient. The marrow cavity must be explored.

(2) Saucerize and Remove All Diseased Bone.—The question of how much bone to remove has always been a debatable one. The difficulty is more apparent than real. The disease is a thrombo-embolic phenomenon and one finds that the involved cortex is bloodless, pale and lusterless even when exposed very early. It should be remembered in this connection that some of the extensive bony changes noted in the roentgenogram may be merely collateral and of relative importance only. On the other hand, it is not uncommon to find more extensive involvement at operation than is delineated roentgenographically. The metaphyseal region should always be thoroughly explored when in doubt. Preliminary drilling of the cortex helps to locate actual pus formation. Following exposure of the area as indicated clinically, an adequate sculptured window in the bone will insure proper drainage. If there is evidence of demarcation, it is important to remove a layer of the contiguous healthy bone. By shallowing or saucerizing the cavity, all overhanging ledges which might hinder drainage are obliterated. The cortex may be cleanly and rapidly removed with a motor saw if so desired.

The question of curettement is a pertinent one. In very early acute cases a conservative attitude is permissible. Marrow sequestra are small and will become extruded spontaneously at a later date as they form. In the presence of frank suppuration and necrosis the marrow cavity may be gently curetted out. Vigorous scraping is not necessary and must be avoided; in this way the remaining endosteal layer is at least partly preserved. During the later stages of the disease when considerable débris and numerous small sequestra are present it is permissible to employ a more thorough curettage. It is helpful to remember that fragments of bone that are firmly anchored may be left *in situ*. When a large tubular sequestrum is present it should be removed by sufficient unroofing to insure a thorough débridement of its bed. Sometimes it is necessary to saucerize the bone from end to end. By careful inspection it will often be noted that intervening healthy viable cortex lies in the path of the proposed excision. These may well be left attached and will shorten the time of convalescence. Care in this respect also lessens the chances of pathologic fracture. In other instances, the situation presented is the extensive destruction at both metaphyses with an intervening bridge of healthy tissue. In such cases the exposure may be made by one sweeping incision which is later sutured over the intact area. Subperiosteal resection as a primary procedure is not to be encouraged except in pelvic localizations. It is the most frequent cause of pseudo-arthrosis in osteomyelitis of the long bones. The most favorable time to perform such resection is when the infection has subsided and definite evidence of involucrum formation has occurred, which is demonstrable in the roentgenogram. This procedure should

be limited to parts of the body in which there is some other bony support, and should practically never be attempted where there is only one bone in the extremity, as in the femur.

Epiphyseal involvement requires fine surgical judgment in its management. When in doubt as to the exact extent of the lesion, a conservative attitude is indicated for the time being. In the presence of definite suppuration and necrosis, a thorough débridement should be performed as elsewhere to prevent a possible extension of the process with its attendant joint complications. Great care must be observed in this situation to avoid opening the joint unnecessarily at the sites of attachment of the capsular structures. When an adjacent joint is involved both situations must be dealt with at once. Waiting for one focus to heal before attacking the other merely prolongs the disability, destroys further the integrity of the untreated structures and encourages continuous reinfection.

As a general prophylaxis against subsequent pathologic fracture, it is wise to narrow down the troughing process wherever it is consistent with a thorough removal of all the diseased bone. This applies particularly to chronic cases as extensive removal of bone is seldom indicated in the early stages of the disease, especially the femur.

(3) Dry the Cavity Thoroughly; Use Tincture of Iodine and Alcohol.—Antiseptics play absolutely no other part in the treatment. It is here used only in the listerian sense—to exclude possible secondary contamination at the time of operation. The entire wound is generously flooded with tincture of iodine and then with alcohol. It is most important to dry the cavity as thoroughly as possible. Gauze wrung out in hot water will control practically all hemorrhage. The antiseptic, as advised, also has some hemostatic qualities. On rare occasions where the situation has demanded very extensive removal of bone, and control of hemorrhage is not satisfactorily accomplished, the writer firmly packs the entire wound wide open with large iodoform gauze packs for 24 to 48 hours, which are then replaced by the usual vaseline pack. *Control of hemorrhage locally and conservation of blood in general is facilitated by the use of a tourniquet for all extensive operations.*

(4) Pack Wide Open, but Not Tightly, with Vaseline Gauze.—Adequate pressure from this non-irritating pack keeps the wound open without repressing the growth of granulations. Care must be taken to lay the vaseline gauze into the wound *lightly*. This is the simplest yet most difficult part of the technic to master. The vaseline must have a fairly high melting point. The gauze strips should measure, ordinarily at least, three inches in width of double thickness and be 12 inches long. These should be most generously impregnated with vaseline. Light packing of the wound is imperative. However, it should be smoothly and carefully placed in the deepest recesses of the wound into the very bony crater. It should just fill the operative sinus and should not be folded over its edges to impede subsequent drainage. Next, strips of vaseline gauze are carefully placed on the skin up to and not over the wound edges. The skin should be covered all around for at least 8 to 12

inches. In some cases where copious drainage is to be expected the entire segment of the limb affected may be so encased. The careful observance of this detail will absolutely prevent any tendency to excoriation of the skin. A generous combination gauze dressing now follows, again at times encasing the entire segment of the limb. Voluminous padding before the plaster case is applied makes for added comfort and increases the absorptive capacity.

The vaseline pack serves several useful purposes from the local standpoint of surgical infection because it meets all the mechanical requirements necessary to maintain ideal drainage. It obliterates dead spaces. It is a non-irritating substance and can be utilized for the maintenance of a patent operative sinus as long as is indicated. The pack and plaster case immobilization maintains the operative sinus almost rigidly immovable. This is of prime importance because the ordinary bacteria are non-motile and depend upon their lodgment along muscle planes and even in the wound upon simple mechanical factors like any foreign body.

(5) Immobilize the Affected Part in a Plaster Case with the Limb in the Neutral Position.—This is a most important part of the technic. Absolute physiologic rest is thus obtained. The plaster case serves first to alleviate pain, eliminates subsequent deformities, and facilitates healing. Utilization of the postoperative encasement will permit even corrective bone procedures in order to procure proper alignment when indicated. There should be no halfway measures about proper retention of the affected part. A plaster case is the best means of gaining this end. The joints above and below the lesion must be immobilized. The constitutional benefits of plaster case immobilization are strikingly evidenced by the rise in temperature that occurs during changes of dressing. Immobilization and rest do not necessarily cease with the healing of the wound. They must be continued persistently until functional stimulus has produced the proper architectural reconstruction in the bone. Therefore, braces should be worn for six months to a year after the wound has healed. In this way recurrences will be minimized because of this prophylaxis against reactivating trauma.

The only indications for postoperative inspection of the wound are pain and persistent temperature. Usually, the patient pays little or no attention to the odor. It is to prevent secondary infection that the infrequency of dressings is urged. When healing proceeds uneventfully the pack is gradually extruded spontaneously. When granulations have definitely lined the bony cavity the most important phases of healing have taken place and a rapid completion of the convalescence may be expected, especially in those situations where there is naturally an adequate overlying layer of soft tissues. It is remarkable how soon and with what facility the soft parts can heal over in spite of an active bony process. This tendency to soft part agglutination must be especially guarded against in the femur, sacro-iliac joint, ischium and spine. It is a safe rule to allow closure by removal of the last vestige of vaseline when the drainage is scant and watery, the granulations are healthy and

beefy red in color, and when there is no evidence of small or large sequestrum formation.

Dressings may be changed at variable periods. As long as the postoperative course is uneventful it is unnecessary to change dressings more often than every four to eight weeks. It is a good idea to change the first plaster case at the end of two weeks because of the copious initial drainage. For the next two or three months, depending on the extent of the operation, the intervals are longer. The examination may be made through a window in the case. The prevention of secondary infection is one of Orr's major premises. It is possible to check this by bacteriologic examination of the wound at each inspection. With the proper care and technic the same organism will be repeatedly recovered, as demonstrated in a number of cases in this series. The bacteriologic examination will also serve as an index as to the progress of the wound. Closure may be anticipated and encouraged when the exudate is free from organisms. The patient is hospitalized only as long as an irregular temperature persists. After extensive operations it is advisable to change the plaster encasement and dressings under anesthesia. The postoperative and convalescent plaster case will never be omitted by one who has noted the absolute relief of pain obtained by this means.

Modifications of this technic are occasionally indicated. When both lower extremities have been operated upon, adequate immobilization is obtained by the application of two long leg encasements fixed by a rigid cross bar. This facilitates nursing care and allows the patient to sit up when the general symptoms have subsided. In adult situations where prolonged supine position, incident to hip spica fixation, is contra-indicated for any reason, this method is most suitable. With joint involvement this method may be combined with traction applied directly to the cross bar.

Operation Through a Window in the Case Applied Before Operation.—Several situations demand that this refinement of the technic should be observed. Operations performed in this manner lessen the operative period, alleviate unnecessary handling and movement of the parts, permit extensive operation, minimize postoperative fracture and greatly reduce the incidence of shock.

The chief indications for operating through a window in an adequately applied plaster case are: poor general condition of the patient and extensive lesions requiring wide resection of bone; profound toxemia in the early stages of the disease. The case should be carefully applied and an adequate window cut out at the site that has been previously determined to be the approach of election. The edges of the window are then protected with oil silk or some other moisture proof or resistant material. The life of the case is prolonged materially by the use of thick absorbent gauze pads applied uniformly so that they may serve to soak up excessive drainage. The width of the window must be at least one third of the circumference of the limb in order to permit adequate retraction of the soft parts during operation. The

length of the window, to avoid embarrassment in limiting the extent of the incision, approximates the segment of the affected limb.

Initial double lesions often require operation at one sitting. The amount of surgery indicated depends primarily upon the general condition of the patient and only secondarily upon the extent of the local lesions. It has been the experience of some surgeons that as a rule too much should not be done in the way of radical removal of bone when more than one focus is attacked at one operation. By observing the technic of operating through a window in the plaster case two extensive débridements may be rapidly accomplished. A definite rule to follow in the light of clinical experience is that the most active and extensive lesions should receive the first and most aggressive considerations of the surgeon.

Application of Fixed Traction.—Fixed traction indicates that some form of skin or skeletal traction is necessary to obtain the desired position and length of the limb, and that the subsequent maintenance of this position is dependent upon the fixation or incorporation of the traction device in the plaster case. The chief indications for this form of immobilization are in the treatment of compound and pathologic fractures; where extensive débridement predicts possible fracture; for all situations demanding circumferential subperiosteal resection of bone; in contiguous bone and joint infections, and in joint contractures which are corrected and difficult to control. Moleskin or adhesive skin traction will suffice in many cases, but the most efficient form of traction and plaster case fixation is obtained by skeletal means, preferably a rigid steel pin. The method of traction is wholly determined by the pathologic condition present. Skin traction is adequate for all situations where no actual shortening, overlapping, or deformity of the bone exists.

Secondary Operation.—Orr's operation is a primary procedure and no further operation is required as a rule. It must be evident that secondary operation may be necessary in some instances of the disease. The majority of secondary operations follow in the wake of a small group of fulminating lesions which are attacked early, but of necessity inadequately, and consequently go on by contiguous thrombophlebitis, to destruction of the remaining portions of the shaft.

When pain and high fever persist over a period of several days the wound should be carefully examined. Most frequently these symptoms are due to improper insertion of the pack or inadequate drainage of associated fascial plane collections of pus. If manipulation of the dressings does not alleviate these symptoms it is wise to reexplore the wound and its vicinity under anesthesia, and to deal with the situation as indicated. While the relief of preoperative pain is immediate after treatment by this method, the subsidence of the fever is seldom as spectacular. It generally is restored to a normal level by lysis over a varying period of time, and is conditional upon the duration of the disease, the extent and location of the lesion, the presence or absence of a bacteremia or other foci, and the adequacy of the operation. Pelvic and other extensive inaccessibly situated lesions continue to exhibit

low grade or moderately increased irregular fever for a variable period even after the most radical operative procedures. One must be very conservative regarding the necessity, therefore, of an early secondary operation. The primary causes for reoperation in the later stages of the disease are usually sequestrum formation, persistent dead space, and irregular soft tissue sinus formation. A sequestrum that does not extrude spontaneously or one which cannot be located and extracted with forceps during the change of dressings, should be removed by operation just as soon as it is evident, the general condition of the patient permits, and when no other local or general contraindications to operation are present. The same holds true for persistent residual bony cavity formation. In both situations the walls of the cavity must be thoroughly cleaned out and given another chance to heal from the bottom. Occasionally, a small bony cavity is completely filled in by an infected fibrous scar. Radical excision is necessary.

Old persistent sinuses must be eradicated. Many sinuses continue to drain simply because they are lined by a dense layer of chronic granulation tissue. When there is no underlying deep seated bony infection and the sinus is not tortuous or too deep, simple curettage may effect a cure. Tortuous sinuses must be followed up and laid wide open. Radical excision and suture except for drainage at the most dependent portion is necessary for its complete eradication and cure. Injection with a radiopaque solution and roentgenologic examination will indicate the devious extent of the lesion and whether or not it communicates with a bony focus. The latter is more satisfactorily determined at operation. Injection of the sinus with methylene blue facilitates its exploration. When a bony focus is found as the basis for the persistent sinus it should be thoroughly cleaned out. The sinus is widely excised and carefully sutured up to the point where direct dependent drainage can be established and maintained for a reasonable period.

Bozan's recent contribution in the treatment of chronic osteomyelitis, whereby an attempt is made to revitalize osteonecrotic areas by drill holes as in aseptic areas of bony necrosis, should be given serious consideration. In extensive chronic involvements the technic might be of value as a supplementary procedure to the Orr method.

General Constitutional Considerations.—The preoperative care is the same as for any major surgical procedure. It may be necessary to transfuse the patient before and after operation. We have found that repeated small blood transfusions are more efficacious than a single large one. When an extensive operation is planned, 500 to 1,000 cc. of 10 per cent glucose in normal saline given intravenously during the operation minimizes the shock. When the acute signs and symptoms have subsided, a careful search and eradication of all foci of infection is in order. In a general way, the patient's constitutional condition is cared for as systematically and rigidly as for tuberculosis. On the other hand, it is one of the most remarkable features of the Orr method to observe with what rapidity the general condition of the patient is improved, as evidenced by a gain in weight, general happy disposition and

maintenance of a high level red blood count. The presence or absence of a bacteremia or general blood infection does not modify the indications for treatment in principle, except in so far as it affects the general operative risk. The prognosis should, however, be guarded when a bacteremia is present. The extent of the operation should be limited only to what is absolutely essential in a septic patient.

SUMMARY

An experience embracing 323 cases of pyogenic osteomyelitis treated upon the principles advocated by Orr warrants our confidence in this system of treatment as a method of choice in pyogenic osteomyelitis. The Orr method standardizes the treatment of a disease whose variable manifestations are more apparent than real. The technic is based on the principles of adequate drainage and adequate immobilization and rest. It alleviates pain and suffering and is at the same time an economic procedure as it lessens the period of hospitalization and permits the ready transportation of the patient. Loss of limb and life is minimized. Deformities are minimized or prevented. It is the only treatment that satisfies the tenets of Orthopedic Surgery.

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END-RESULTS OF EXCISION OF THE ELBOW*

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Camden, N. J.

While it may seem heresy to advocate excision of the elbow rather than arthroplasty in all patients in the laboring classes, still to quote Lovett and Jones in the rewritten section on Stiffness of Joints in their Orthopaedic Surgery: "It is an open question whether this operation—arthroplasty—has sufficient advantage over excision to warrant one in pronouncing it the operation of election."

Certainly arthroplasty cannot be performed with hope of good results in all cases of stiff elbow, as all writers agree that the causative trauma or arthritis must not have been so great as to severely distort the joint and peri-articular structures, and that there are definite indications for the operation of excision in those cases which represent end-results from the graver traumata and infections.

Tuberculosis of the elbow seems the only condition where all are in accord that excision is the operation of choice. It should not be done before growth has stopped, that is, after 18 years of age, but it is interesting to note that in 1874 John Ashhurst, Jr., in commenting at length on eight cases of excision of the elbow, reported five patients operated upon in the first decade, and he refers to 119 cases collected by Hodges of Boston in which six were ten years of age or less. Incidentally, Hodges reported 15 deaths and 15 others requiring subsequent amputation in this same series.

In 1839, Bier reported a case of successful excision of the elbow. In 1905, Murphy first advocated the fascial transplant in arthroplasty, since which MacAusland and Campbell both have developed excellent technics which are accepted as satisfactory by other operators.

During the war, the French tried and gave up excision of the elbow for gunshot wounds, whereas many English reporters, notably A. E. Moore, W. M. Shepherd, C. M. Moullin, R. H. J. Swan and C. H. Fagge in the British Medical Journal in 1917 and 1918, and R. A. Stoney in the Dublin Journal of Medical Science in 1917 and 1920, wrote extensively on its value as an immediate treatment accompanying débridement for gunshot wounds destroying the elbow joint. They claimed it gave free drainage and the earlier it was done the better the end-result, infection and sepsis being prevented or more easily combatted without the development of an enormous mass of callus. All agreed that the triceps tendon and fascia should be kept intact and continuous with the periosteum and fascia overlying the ulna, and that these structures should not be divided transverely as was seen by Stoney,

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of Ireland, in several patients operated upon by German surgeons during the war.

Arthroplasty was originally introduced as a refinement of excision in which fascia was inlaid and less bone removed, thereby hoping to render the joint more stable laterally and also to give full and free painless active motion. It would seem that in a non-weight bearing joint such as the elbow, where lateral stability is not so important, but where painless motion and function are of great value, especially in manual laborers, excision is the operation of choice regardless of the lesion. The length of the convalescent period plus the necessary physiotherapy also must be considered in evaluating a procedure, in patients who are dependent upon the use of their hands to earn a livelihood. An elbow not subjected to severe physical strain is much more likely to give a satisfactory functioning result than that of a laboring man following arthroplasty, and it seems to me that all other things being equal the patient's occupation and future physical needs should be the determining factor in deciding on the type of operation to be done rather than the anatomic beauty of the part in this class of patients.

Certainly the results in resection of the elbow are not as claimed by many, unsightly and unsatisfactory, in that the joint is flail and weak, and always requires an external appliance for function. It may be a crude surgical procedure, as stated so often in the literature, but if the patient is satisfied and can freely and vigorously use the part in his work without pain or secondary traumatic arthritis, it is not an operation to be thrown into the discard in favor of one that is technically beautiful. However, the patient has rarely more than 50 or 60 degrees of motion in light occupations only, and if not constantly cared for the joint will become the seat of pain and increasingly diminished function and even eventual re-ankylosis.

Many writers say that, unless the patient is a fit one for an arthroplasty, it is better to do an osteotomy to permit of re-ankylosis in the position of choice than to do an excision. Campbell says in speaking of arthroplasty, "Unless a durable stable joint which will stand average daily use is restored, a joint ankylosed in the most useful position is far more serviceable." I wish to take issue with him unless he means that an ankylosed joint is better than one the seat of a poor arthroplasty, because a patient with a properly excised elbow is vastly better off than with a stiff elbow, no matter what the position. However, there is no advantage in a few degrees of stable motion with pain on excessive use over an excised elbow if only moderately flail. The results even in carefully selected cases cannot be foretold in arthroplasty whereas they can be prognosticated in almost any type of case where an excision is done. Intelligence, persistence, grit and a willingness to spend time are very essential to the result in arthroplasty, whereas they are not so essential for a good postoperative result in excision.

In 13 cases of a series of 14 upon whom I have done 15 excisions of the elbow by the same technic, the results have been quite satisfactory both to the patients and to myself. The other one who has been operated upon twice

is not improved. Three operations were for tuberculosis in patients aged 39, 58 and 64 years. Nine were for posttraumatic ankylosis, all old healed compound comminuted fractures, one for an acute extensive compound comminuted fracture of the three bones from which the upper end of the ulna had been lost. The average age of these patients was 31.2 years, the youngest 18, and the oldest 44. The fourteenth patient upon whom I have operated twice, each time with recurrence of ankylosis, had a very extensive typhoid osteomyelitis of the humerus of four years' duration which had been previously cleared up, except at the elbow, and who had bony ankylosis both of the elbow and shoulder. Two of the three tuberculous patients were females and two of the nine posttraumatic ankylosis cases were females. The acute case and the typhoid osteomyelitis case were males.

The technic consists in a longitudinal incision five to six inches long, over the middle of the posterior aspect of the arm, centering over the tip of the olecranon and extending down over the ulna splitting the triceps and its fascia, extension into the forearm, and the periosteum of the humerus and ulna. The periosteum is carefully and completely elevated from the humerus with the attached flexor and extensor group of muscles attached to the condyles, and joint capsule en masse. The ulnar nerve is carefully separated from its groove together with the periosteum and other structures. The periosteum is then separated from the olecranon and ulna on either side down to the coronoid and radial head, at which stage the humerus is sawed through just above the condyles, three-fourths of an inch above the joint level. This greatly facilitates the subperiosteal dissection of the anterior aspect of the ulna and radius with the overlying joint capsule, because it permits drawing the upper ends of these bones out of the wound and thus it is not necessary to disturb the ankylosis and perhaps light up any latent infection by osteotomizing through the joint as in an arthroplasty. The forearm bones are then sawed off together at the same level just above the bicipital tuberosity of the radius and just below the coronoid process, thus removing about five-eighths of an inch of bone below the joint level of the elbow approximately one and one-half inches in all. Sharp bone edges are rongeured off. The periosteum, capsule, muscles and fascia are sutured interruptedly in two layers, being careful to cover the denuded bones, and the skin is closed with a continuous lockstitch suture. Bone wax may or may not be used to seal over the bone ends. A rubber tissue drain is inserted to care for oozing in the dead space. An internal right angle plaster splint is applied. The drain is removed in 24 hours and the splint replaced by a sling at the end of 12 days, when the sutures are removed. Passive and active motion are begun immediately and massage instituted if the muscles are too atrophic. The sling is kept on for three months to prevent overstretching the contracting muscles, especially the biceps, but the patient is encouraged to remove the arm from the sling and use it as actively as possible.

Pain is almost a negligible factor from the time of operation, and is always gone when motion begins. As a rule, within a week there is 20° to 30°

of active flexion against gravity which increases to 90° and is strong within three months, and which continues to improve for a year. Extension against gravity, that is holding the hand extended above the head, is the last function to recover, although weak extension against resistance appears about the third month, and continues to improve toward optimum for about two years. Within a year the patients learn to hold both biceps and triceps moderately tight when the arm is hanging at the side which does away with the lateral instability at rest, which is so objectionable to some. When strongly flexed there is practically never any instability at any time.

All of the males herein reported earn their own livelihood by hard physical labor, thereby increasing their muscle tone and decreasing instability, and in spite of a year or more of elapsed time at work in all but two cases, not one complains of pain either on use or at rest.

The range of flexion in the 12 successful cases is full and powerful muscular action except in the case of nonunion of the humerus and this is up to 60°, a range of 120° even here. All but one have full extension, and he lacks only 15° but since he flexes strongly to 45° his range of motion also is 120°.

Roentgenologically, all cases have developed since operation many exostoses or apparent individual bony growths from the disturbed periosteum remaining *in situ*, but from a clinical point of view these excrescences cause no symptoms and are only questionably palpable. The postoperative roentgenograms, however, are not ideal in appearance.

There was one death in the series, perhaps precipitated by surgery, in which a female, aged 58, with severe rheumatic heart disease and mitral stenosis complicating tuberculosis of the elbow, definitely a poor operative risk, whose heart lesion was judged by the cardiologist to be aggravated by the toxemia and pain from her elbow, had an excision done. The patient died on the sixth day postoperative from acute cardiac failure.

Case Reports

Case I.—H. C., female, aged 64. Disability elbow for four years previously. Diagnosis, tuberculosis with sinus. Excision, January 20, 1927. Entirely healed by July, 1927. One year later, January, 1928, full flexion and could hold extended against gravity at 135°. Disease inactive. Although now living in another part of the state, her family reported in 1931 that she had full use of her elbow and that it caused her no trouble.

Case II.—M. B., female, aged 58. Disability elbow for one year previously. Diagnosis, tuberculosis, complicated by rheumatic heart disease, mitral stenosis and increasing decompensation, thought by cardiologist that it was being made worse by disease of elbow. Excision, April 9, 1934. Death on sixth day due to acute cardiac dilatation.

Case III.—B. D., male, aged 39. Disability followed injury in 1927. Diagnosis, tuberculosis with sinus formation. Excision, February 8, 1932. Wound healed by June 6, 1932, with full flexion present and extension against gravity at 150°. Not seen since although returned to full duty as a bakery laborer. Disease quiescent.

Case IV.—W. L., male, aged 31. Compound comminuted fracture all three bones about elbow with loss one and one-half inch upper ulna, including olecranon, August 20, 1930. Excision and débridement of injured area, in presence of rather active infec-

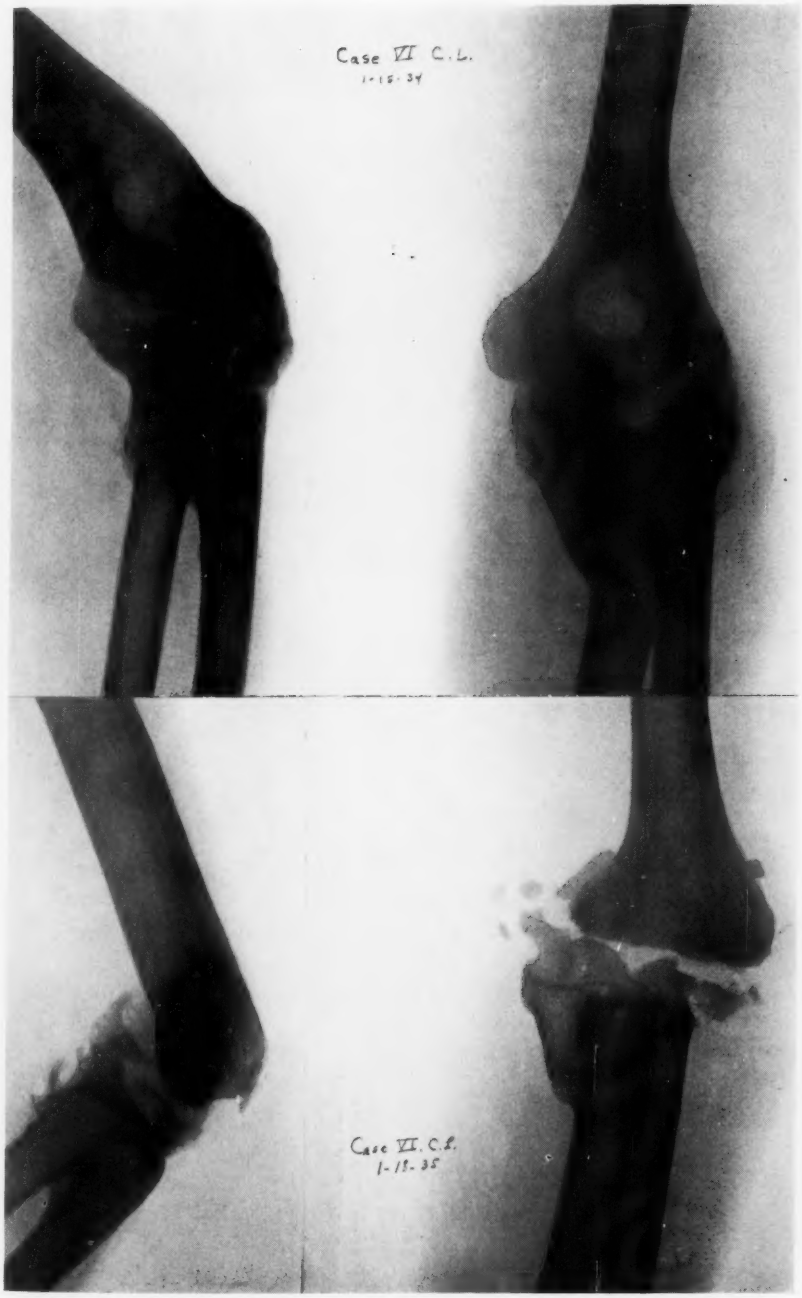

FIG. 1.—Note solid preoperative ankylosis and bony débris about the joint postoperatively.

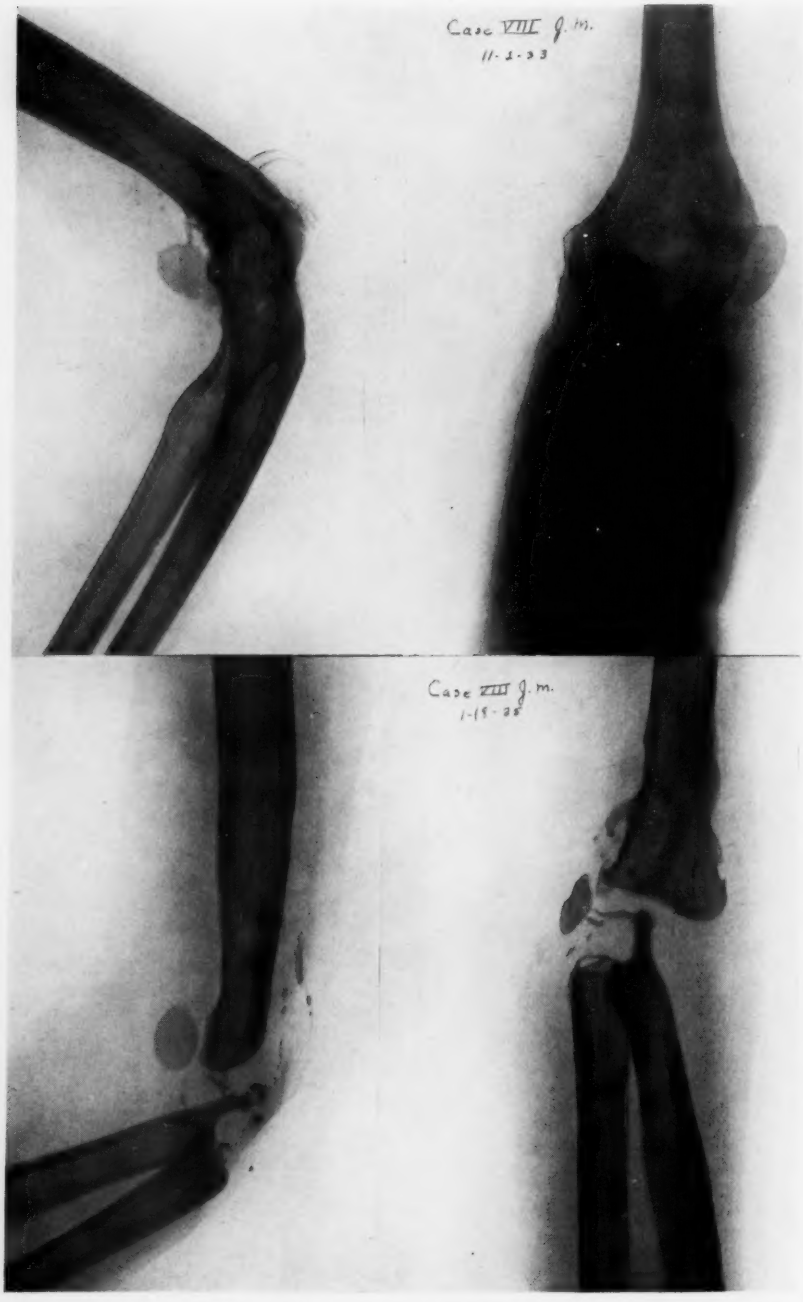

FIG. 2.—Note solid bony ankylosis preoperatively and regeneration of spur of bone from radius postoperatively.

tion, with repair of lacerated triceps August 28, 1930. Wound drained profusely for one month, then only mild seropurulent discharge until November 1, 1930, when the wound became solidly healed. Motion was urged after the severe drainage lessened. When last seen about February 1. 1931, had strong flexion to 30° beyond a right angle and almost full extension against gravity.

CASE V.—L. Y., male, aged 28. Compound comminuted fracture elbow August 20, 1931. Healed about January 1, 1932, ankylosed at 155°. Excision, February 12, 1932. Entirely healed, March 11, 1932. By March 29, 1932, he had flexion to right angle against gravity, and by April 22, 1932, full flexion was possible, and by May 17, 1932, was able to drive a truck. Physiotherapy was begun March 19, 1932, and stopped April 22, 1932. When last seen in February, 1934, had full flexion against resistance and full extension against gravity and considerable resistance.

CASE VI.—C. L., male, aged 44. Sustained severely comminuted and compound fracture of the elbow May 27, 1933. Wound entirely healed in December, 1933, ankylosed at 140°. Excision January 10, 1934. Postoperative wound healed February 14, 1934. By May 2, 1934, there was very strong flexion to 15° beyond a right angle, and by June 13, 1934, he had returned to work as a fireman and was able to hold his arm fully extended against gravity (Fig. 1).

CASE VII.—L. McG., male, aged 26. Sustained compound comminuted fracture of elbow May 4, 1929. Wound healed July 26, 1929. Elbow ankylosed at 120°. Excision, November 26, 1929. Wound was healed within a month and on May 20, 1930, had full flexion and extension against gravity and resistance.

CASE VIII.—J. M., female, aged 21. Sustained compound comminuted fracture elbow November 27, 1932. Wound healed in May, 1933. ankylosed at 90°. Excision, November 2, 1933. Wound healed November 24, 1933. By January 22 1934, had full flexion against gravity and resistance. Extension against gravity is still weak but improving. Working as an assembler of radios (Fig. 2).

CASE IX.—T. T., male, aged 18. Severe simple fracture lower humerus December 24, 1929. Ankylosis at 90°. Excision, November 2, 1932. Primary union. By January 10, 1933, his range of motion was strong from 165° to 75° and now from full flexion to 165° extension strong in both flexion and extension and working as a helper on a truck (Fig. 3).

CASE X.—E. B., female, aged 36. Sustained comminuted fracture head right radius on May 23, 1934 which was excised on May 28, 1934. Primary union. Physiotherapy begun June 20, 1934. On July 7, 1934, there was present posterior dislocation of the elbow with much extra-articular callus and ankylosis at 90°. Excision, October 8, 1934. Now strong flexion to 90°. Slight triceps action only. Improving constantly (Fig. 4).

CASE XI.—L. F., male, aged 34. Sustained compound comminuted fracture of all bones about elbow and a compound fracture of the middle of the humeral shaft, ankylosis at 90°. Still had sinus from elbow and middle humeral shaft on October 14, 1933, when excision done. Elbow healed, January 28, 1933. Sequestrectomy of humerus, September 5, 1934. Entirely healed, October 31, 1934. Full flexion although not strong. No extension against gravity as yet.

CASE XII.—A. A., male, aged 36. Sustained compound comminuted fracture about elbow and fracture middle humeral shaft in September, 1930. Ankylosis elbow at 90° and non-union humerus. Bone graft of humerus September, 1932. Graft absorbed. Excision elbow March 10, 1933. Primary healing. At present working as farmer with leather cuff for humerus. Very strong flexion to 60°. Extension against gravity to 135°. Awaiting open fixation of humeral fragments.

CASE XIII.—W. McC., male, aged 38. Extension comminuted fracture all bones at elbow with fractures of radius and ulna in forearm at lower levels September 28, 1934.

FIG. 3.—Note absence of olecranon and deformity of lower humerus preoperatively and calcific deposits postoperatively.

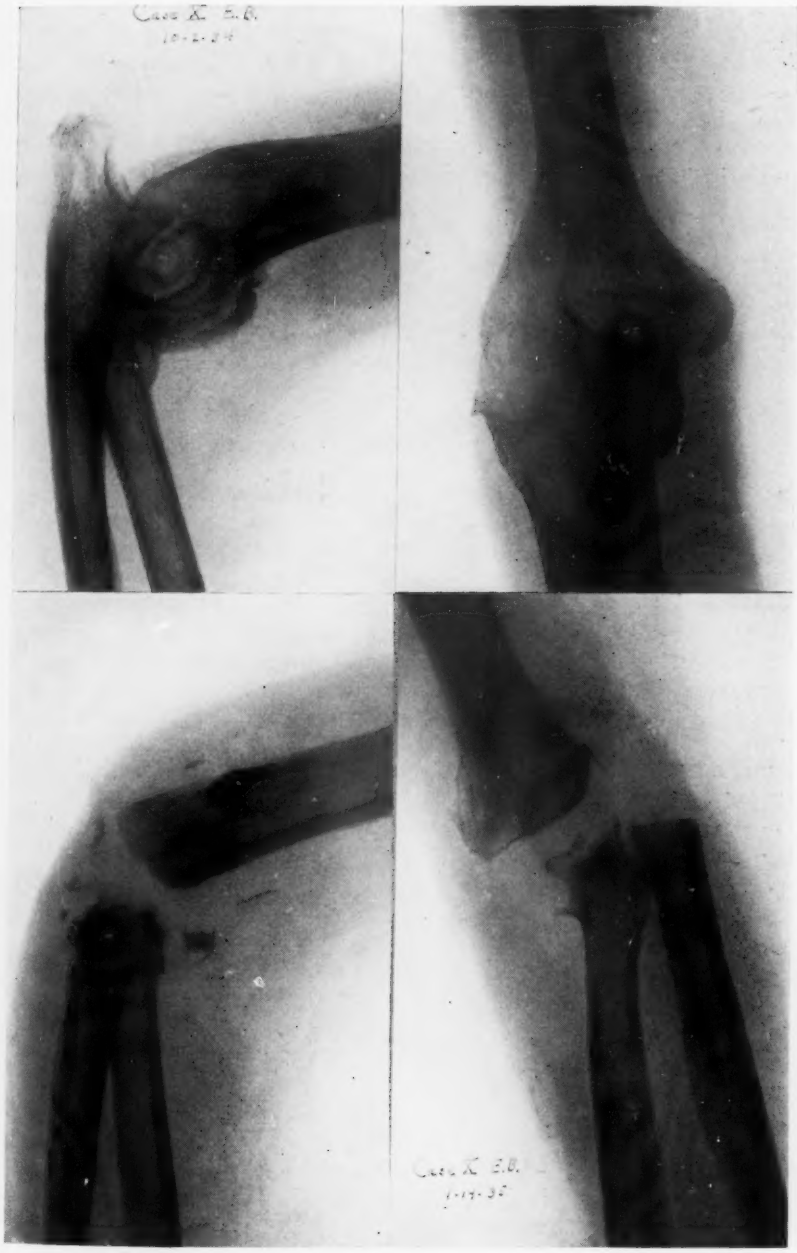

FIG. 4.—Note ankylosis with posterior dislocation of forearm bones and small amount of postoperative débris.

Forearm fractures fairly solid by January 16, 1935, and elbow ankylosis at 165° when excision done. Primary union. Still in splint.

CASE XIV.—Male, aged 19. Typhoid osteomyelitis entire humerus with ankylosis shoulder to side and elbow at 110°. Guttered and treated by Orr technic in November, 1930. Healed, all but at elbow, where sinus still existed in January, 1932. Primary excision done then. Rapid regeneration of bone and re-ankylosis. Wound healed in three months. Reexcised October 5, 1933, with primary union, but again regeneration of bones closely resembling in shape the portion of elbow removed. Ankylosed at present at 170°. Possibly a third excision may be performed.

CONCLUSIONS

While this is a small series of cases on which to base any opinions in such a controversial matter, I bring them forward as a plea for the operation of excision of the elbow in those cases where arthroplasty does not give the best outlook.

DISCUSSION.—DR. JAMES MARBLE (Boston, Mass.). Some ten years ago, Dr. James M. Hitzrot, of New York, recommended the excision of the lower end of the humerus in cases of comminuted bimalleola fractures of the lower end of the humerus. These cases seemed to give very excellent results, although there was some lateral instability at the elbow. It was following Doctor Hitzrot's demonstration that I operated upon an artist with a compound comminuted fracture of the lower end of the humerus in whom the bone was shattered into many pieces. The result was very satisfactory. The patient had a full range of motion but with considerable lateral motion. She was able to resume her former occupation and has a very useful arm.

The cases Doctor Buzby has demonstrated seem to be very satisfactory. He has excised the elbow joint, removing about one and one-half inches of bone. It is all done subperiosteally. The resulting motion is excellent. There is a moderate amount of lateral instability. The patients can initiate flexion. The muscular power is good. The grasp of the hand is excellent. They can all do hard work.

The operation, as it is described, seems relatively simple. Certainly his results are very satisfactory.

DR. HENRY P. BROWN, JR. (Philadelphia), asked if any effort was made to retain the motion of the triceps.

DOCTOR BUZBY.—In answer to Doctor Brown's question, by splitting longitudinally through the triceps fascia over the tip of the olecranon down into the forearm and the periosteum of the humerus and ulna, the insertion of the triceps is not disturbed, in that the periosteum and fascial covering on the ulna have not been disturbed. The triceps contracts sufficiently eventually so that with its fascial insertion it is possible to extend the ulna.

BRIEF COMMUNICATIONS AND CASE REPORTS

TOTAL REMOVAL OF PAROTID GLAND WITH PRESERVATION OF FACIAL NERVE*

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CASE REPORT.—Andrew K., aged 38, an auto mechanic was first seen December 24, 1934, complaining of a tumor in the region of the left ear. He had first noticed, about six months before admission (June, 1934), that his left external auditory meatus seemed to be getting smaller. There was also a dull pain, and a diminution in his hearing on that side. About one month later, he noted a lump behind the left ear—the size of a finger tip. Two months ago (October, 1934) an enlargement in front of the ear appeared which has rapidly increased in size and consistency. The nodule behind the ear was excised November, 1934. For the past two weeks the pain in front of the ear had markedly increased.

Examination was negative except for the local condition in the region of the left ear. The ear lobe sticks out somewhat and the face, in front of the lower portion of the pinna, is visibly larger on the left than on the right. This is caused by a dense stony infiltration underneath the skin extending from the tragus downward to the lower border of the ear lobe. The induration involves the superficial tissues but is not attached to the skin. It does not involve the angle of the jaw, but is above and behind it, seemingly directly subjacent to the external auditory meatus. The inferior wall of the external auditory canal is pushed up and partially closed and the skin edematous. The ear drum is slightly retracted, otherwise negative.

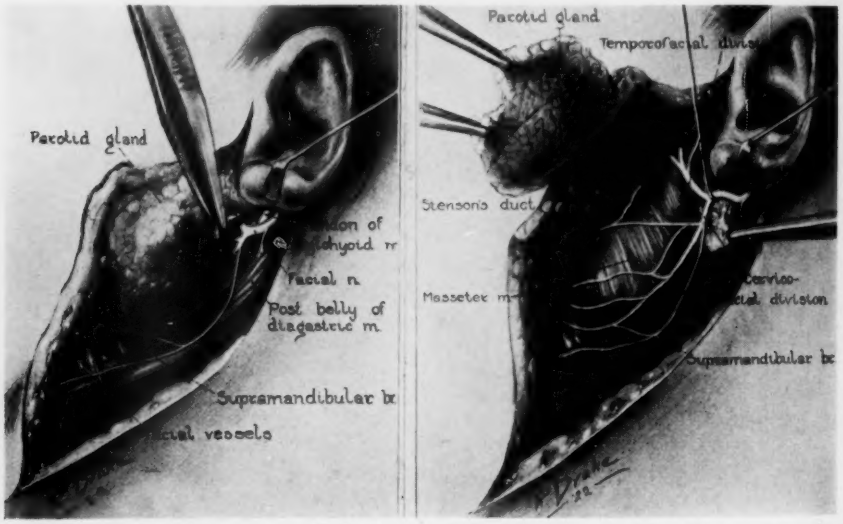
The location of this tumor precluded simple enucleation. It evidently lay deep in the fossa in front of the mastoid, immediately behind the facial nerve and underneath the external auditory canal, and because of its active growth a total removal of the parotid gland appeared justified. Sistrunk[1] and later Adson and Ott[2] have described the removal of the entire parotid gland with preservation of the facial nerve; McWhorter,[3] Shaar,[4] Grove,[5] and others[6] have described removal of these tumors by this method.

Operation.—January 8, 1934.—Under general ether anesthesia, a curved horizontal incision was made below the ramus of the mandible, extending posteriorly one inch behind the mastoid process. The inframandibular branch of the facial nerve was recognized underneath the platysma a short distance in front of the angle of the jaw and three-eighths of an inch below the bony edge. It was about twice the thickness of a heavy silk suture. This was followed carefully up into the substance of the parotid gland. About one-half inch within the gland, it began to curve down into the depth. The skin incision was then extended vertically upward in front of the ear. The gland was incised until the bifurcation of the facial nerve into its upper and lower main branches was reached. With the plexus of the facial nerve fibers thus exposed, the superficial portion of the parotid was next dissected off, using the plane of these fibers as the floor. As Adson and Ott have noted, the facial nerve travels through the gland for a distance of 2 cm. only, and if the vertical incision is made close in front of the ear, there is little danger of injuring it (Figs. 1 and 2). There is a natural embryologic division of the parotid into a superficial portion overlying the facial nerve and a posterior portion beneath it (McWhorter[3]). This facilitates dissection. Malcolm[9] has also described the detailed surgical anatomy of this region.

* Read before the American Society for the Study of Neoplastic Diseases, Washington, D. C., September 6, 1935.

With this part of the dissection completed, and Stenson's duct ligated, attention was now turned to the posterior part of the gland which contained the tumor. The facial nerve was traced, curving downward behind the ramus of the mandible in a trunk the size of a pencil lead, one-half inch above the angle of the jaw. It lay well anterior to the tumor mass. The vertical incision was then curved around the cartilage of the ear, meeting the posterior extension of the original horizontal incision after excising a one and one-half inch triangle of skin behind the ear, widely including the biopsy site. The posterior portion of the parotid was thoroughly excised, hugging the cartilage of the concha, the inferior border of the auditory canal, the anterior mastoid eminence, anterior border of the sternomastoid fibers and carefully removing all vestiges of the gland from the depth behind the facial nerve to the belly of the digastric muscle.

The ear lobe came down easily to fill the skin defect behind it. There was no postoperative reaction or facial paralysis. His hearing returned completely within two weeks.



FIGS. 1 and 2.—The supramandibular branch of the facial nerve is followed up to the under surface of the parotid gland and into its substance to expose the main trunk of the nerve. Note that vertical incision in front of the ear close to the pinna avoids the upper division of the facial nerve (which supplies the eye) and that the ramifying fibers of the facial nerve lie on a plane on the surface of the masseter. The anterior portion of the parotid gland is superficial to this plane and, after this exposure, is easily dissected out. (Courtesy of Doctors Adson and Ott and the Archives of Surgery.)

Microscopic Examination.—(Dr. Charles F. Geschickter). "The section shows a mass of fibrous tissue invaded by cords of very small compressed basal cells with dense nucleus and little cytoplasm. The relative amount of stroma is large. There is no cartilage in the section examined and there also are no solid epithelial nests of cancer. While there is no sharp dividing line between benign mixed tumors of the parotid and basal cell cancer, I would be inclined to place this section with the former."

Roentgen ray therapy was begun two weeks postoperative, receiving 14 treatments, two or three days apart. On May 18, the lymphatics of the neck were removed, using Semkin's[10] technic. There has been no recurrence during the past two years (Fig. 3).

Mixed tumors of the parotid are not very malignant. Many instances are recorded where the tumor remained stationary and unchanged for 30 to 40 years. Nevertheless, a certain number take on active growth later, at times growing into enormous ulcerating masses, extending, in one case we have seen, six inches from the side of the head and rapidly infiltrating the

nodes of the neck and extending into the mediastinum. Most surgeons believe that if completely enucleated they do not tend to recur, but if the capsule is entered, the spread may be rapid. There have been recurrences 20 years after local removal.

The angle of the jaw is the most frequent site of origin. However, they may start posteriorly, anteriorly, or in the upper portion of the parotid, and one should not be misled because the site of origin is not usual. Though reports from radiologists are conflicting, it seems certain that some, at least,

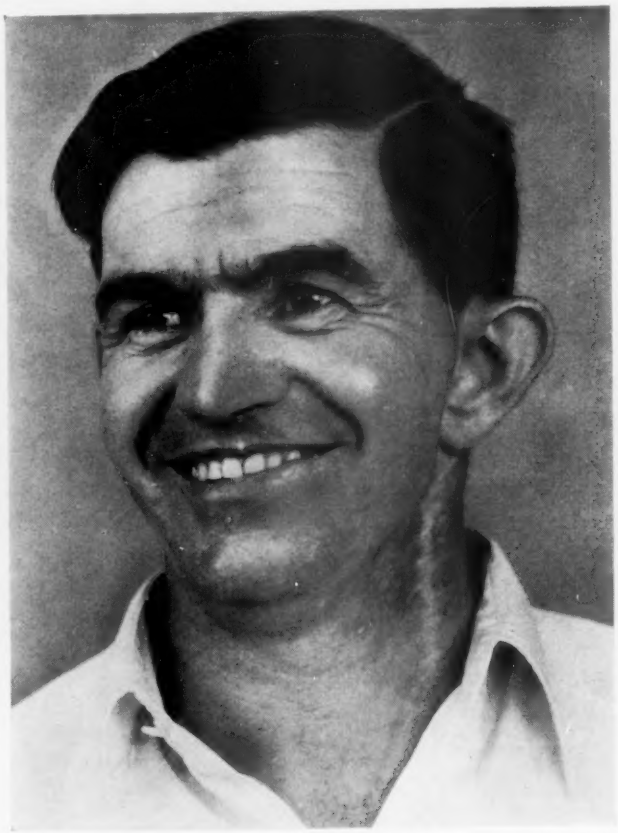


FIG. 3.—Appearance of patient two years after total removal of parotid gland.

of the mixed tissues composing these tumors are not affected by radiation, and only temporary decrease in size is produced by irradiation. No authorities so far as we know consider them radio sensitive.

Stein and Geschickter[8] show clearly that the parotid gland in an 18 Mm. human embryo is an outpouching of the buccal epithelium and the actively proliferating tumor element is an elongated basal cell which transforms into a more cuboidal or columnar type; *i.e.*, epithelial in origin and not endothelial as some have previously held. From its earliest stages, the parotid lacks a specialized fibrous capsule: the epithelial cells diffusely invade the surrounding connective tissue, apparently stimulating this precartilaginous substance

to react and to proliferate. The result is a composite tumor of both epithelium and connective tissue—mixed tumor.

Malignant tumors are of the basal cell type: derived from the basal cell layer of the primitive buccal epithelium from which the salivary glands are derived. They recur and extend locally, but rarely metastasize.

Thus, the difference between mixed tumors and carcinomata is one of degree and clinical course rather than their being distinct pathologic entities.

SUMMARY.—A case of tumor of the parotid directly beneath the external auditory canal is described in which total removal of the parotid with preservation of the facial nerve was accomplished, and who has remained well for two years.

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TOTAL COLECTOMY FOR CHRONIC ULCERATIVE COLITIS*

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CASE REPORT.—A female, aged 16, was admitted to the Pennsylvania Hospital in April, 1927. Her past history had no bearing on her illness which began in August of 1926 with a bloody diarrhea. Within one month she was having 10 or 12 bowel movements daily. The stools contained a large amount of blood and defecation was accompanied by cramp-like pains over her entire abdomen and an intense burning in her rectum. She had an irregular fever. These symptoms continued with occasional remissions and in eight months she lost 30 pounds in weight. She was given a number of blood transfusions and various forms of treatment were tried. A guinea-pig inoculation from the stools was negative for tuberculosis, as were tuberculin tests. It was thought she might have chronic amebic dysentery with secondary bacterial infection, but finally a diagnosis of chronic ulcerative colitis was made. In April, 1927, her hemoglobin was 27 per cent; when discharged to a convalescent home in June, 1928, it was 74 per cent, the diarrhea had abated and she was able to be about the ward. This remission of symptoms lasted until August, 1927, when blood again appeared in her stools and gradually all the former symptoms returned, but with less severity.

Roentgenologic examination after a barium enema showed a gross abnormality of the transverse colon extending distally from the hepatic flexure. The entire colon distal to this was very narrow, especially in the lower portion of the sigmoid. The narrowing

* Presented before the Philadelphia Academy of Surgery, April 1, 1935.

was partly due to spasm as the lumen varied in size during the examination. There was a marked insufficiency of the ileocecal valve.

Proctoscopic examination at this time showed an inflamed mucosa with ulceration. Later proctoscopic examination was impossible even under an anesthetic because of narrowing of the lumen of the bowel. In July, 1929, an ileostomy was performed. The ileum was completely divided about 12 cm. from the ileocecal junction. This operation resulted in considerable relief, but tenesmus and the discharge of bloody mucus from the rectum continued. A rectovaginal fistula developed. Her general health improved greatly, but at no time was she completely relieved of symptoms. She was kept under observation and in January, 1932, colectomy was decided upon. This was performed in two stages. At the first operation, the terminal ileum, the cecum, ascending, transverse and descending colon were removed. The bowel was so friable that it was torn through by the traction of its own weight while the mesosigmoid was being divided. It was necessary to remove the greater part of the omentum which could not be separated from the transverse colon. The sigmoid stump was brought out through the lower part of the wound. Four months later the sigmoid, rectum and anus were removed. Two weeks after this last operation, she developed an intestinal obstruction which necessitated a laparotomy for the division of adhesions. Four months later a similar occurrence took place and again it was necessary to operate upon her and divide bands of adhesion. After this she made a good recovery and for the past year has been employed as a domestic.

The segments of bowel removed at the two operations were hard and covered with firm yellow fat. A large portion of omentum was attached to the transverse colon. The wall of the colon was thickened and so contracted that only a pencil sized lumen was present surrounded by a wall 7 Mm. thick. In the ascending colon, 5 cm. from the ileocecal valve, a point of constriction almost occluded the bowel. The terminal ileum showed some slight thickening. The appendix apparently was not involved in the inflammatory process. Microscopically, the mucosa of the colon was ulcerated in areas. The lymph tissue was quite hemorrhagic and rather loose. The muscularis was thickened with small areas of scar and fibrosis. Scattered throughout all the sections were small areas of localized accumulations of round cells and a few endothelial cells. Occasionally in these areas a multinuclear giant cell was seen, but no central necrosis. The section of ileum showed nothing abnormal. Bacterial stains failed to reveal any organisms in the tissue. A pathologic diagnosis of chronic ulcerative colitis, etiology undetermined, neuromata and fibrosis of the colon was made. Dr. John Bauer who examined the tissues made the following comments:

"The changes shown in the sections are most remarkable. The mucosa is diminished in amount, at many places ulcerated and replaced by granulation tissue. The submucosa is greatly thickened, chiefly by hyaline areas of fibrous tissue devoid of infiltrating cells (probably the scars of former lymphoid centers), a diffuse cellular infiltration chiefly of lymphocytes and a few mononuclears and polymorphonuclears and enlarged hyperplastic lymph follicles. The follicles show marked proliferation of the secondary centers, some mononuclear cell infiltration and epithelioid cells with hyaline patches. The amount of lymphoid tissue is distinctly increased, but everywhere shows inflammatory activity and not neoplastic changes. There is an irregularity in the muscularis due no doubt to the destruction by a continuation of the inflammation from the mucosa and submucosa and subsequent healing. Many collections of lymphocytes are seen. The nerves have become thickened into the form of neuromata. A section of lymph node within the mesentery shows marked hyperplasia, dilatation of the sinuses and a cellular reaction consisting of large flat mononuclears and a few eosinophiles. Here, too, the secondary centers are prominent and contain hyaline deposits. All of the changes suggest a low grade, longstanding chronic infection, in places associated with healing in others with ulceration of the mucosa and accentuated activity. The histologic studies simulate tuberculosis in places but lack the characteristic necrotic foci, epithelioid cells or giant cells. No amebae are seen."

BOOK REVIEW

TUMORS OF THE URINARY BLADDER. By EDWIN BEER, M.D. Baltimore, William Wood & Co., 1935.

This monograph is introduced by an excellent historic sketch, extending from the ancients down to the present time. Real progress, it is pointed out, began with the use of the cystoscope, and the author, in 1910, was the first to use the cauterizing spark inside the bladder for the purpose of treatment. He used the Oudin current. Paskis of Vienna in the following year suggested the use of radium. In 1912, Edwin Beer advocated extraperitonealization of the bladder for operations for cancer.

A good description of cystectomy and transplantation of the ureters into the bowel as well as the skin, which methods have been developed in the last 15 years, are also discussed thoroughly.

Doctor Beer concludes, and the reviewer agrees thoroughly, that deep roentgen ray has proved a dismal failure in the treatment of bladder carcinoma during the last 10 years.

Chapters have been devoted to the incidence of the disease with some discussion of the causation. The biologic characteristics are gone into thoroughly, as well as the pathology and classification of bladder tumors.

The symptoms and diagnosis of bladder tumors are exhaustively considered and the author properly points out that cystoscopy, with the taking of biopsy specimens, as well as cystography, are methods of precision which are most helpful to the examining surgeon.

In the discussion of treatment, all methods have been tried. A painstaking and accurate tabulation of the results obtained with each method is given. There is also a chapter devoted to combination therapy, which is very interesting indeed.

The monograph presents a subject of universal interest, handled by an expert, in a fair and meticulous manner as regards history, diagnosis and treatment by all methods and his results in 600 cases.

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EDITORIAL ADDRESS

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EDITORIAL

THE agreement by which papers presented before the Southern Surgical Association are to be published in the ANNALS OF SURGERY is a very happy solution to some of the problems which confronted both the Council of the Southern Surgical Association and the Editorial Board of the ANNALS OF SURGERY.

Ever since 1887, at the very beginning of the Southern Surgical and Gynecological Association (as it was then named), the papers presented before it have been generally regarded as contributing materially toward medical progress in America.

It is interesting to note the following quotation from Article II of the original constitution of this Association: "The object of this association shall be to organize the profession of the South in the most efficient manner possible for the advancement of the sciences of surgery and gynecology." Article II of the present constitution states: "The object of this association shall be to further the study and practice of surgery in its various departments, especially among the profession of the Southern States." This minor change in its constitution, as well as its name, indicates that the policy of the Council has been altered in order to meet present conditions. The main objective of the association, however, has always been the advancement of surgery regardless of territorial boundaries.

Throughout its 49 years, the Council of the Southern Surgical Association has felt that it was necessary, for the advancement of surgical progress in the South, for the Association to establish and maintain contacts with the rest of the United States. Therefore, it is not surprising to find on the rolls of its membership surgeons from as far West as Washington and California, and as far North as Massachusetts, while Texas and Florida constitute our Southern boundary. During the existence of the Southern Surgical Association its various Councils have evidently felt keenly the necessity and the advisability of sharing with the medical profession of the entire world any progress which might result from its annual meetings. For many years papers presented at these sessions have been published in the leading medical journals of America, principally in those having the largest circulations.

In January, 1935, the fifty-first anniversary of its foundation, there was affected a reorganization of the Editorial Board of the ANNALS OF SURGERY. It is a curious and happy coincidence that both the ANNALS OF SURGERY and the Southern Surgical Association are about a half century old. Their union augurs much benefit to each organization, as well as to the whole medical profession, since both primarily exist for the advancement of surgery through

the production and the publication of the best surgical thought of our times.

In the reorganization, very naturally, the Editorial Board of the ANNALS OF SURGERY was confronted with numerous problems to solve. Chief among these was one of obtaining articles from authors who were able to present surgical subjects authoritatively and satisfactorily. There is no doubt but that the vast majority of papers read before the sessions of the Southern Surgical Association will not only prove to be "satisfactory" to the Editorial Board of the ANNALS and the Editor of the transactions of the Association, but will "further the study and practice of surgery in its various departments" throughout America as well as "among the profession of the Southern States."

All the papers read before the Southern Surgical Association as well as the relevant discussions will be published completely in the Transactions of the Association.

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